

PROPRIETARY



A HISTORY OF IMPERIAL OIL'S ENGINE OILS

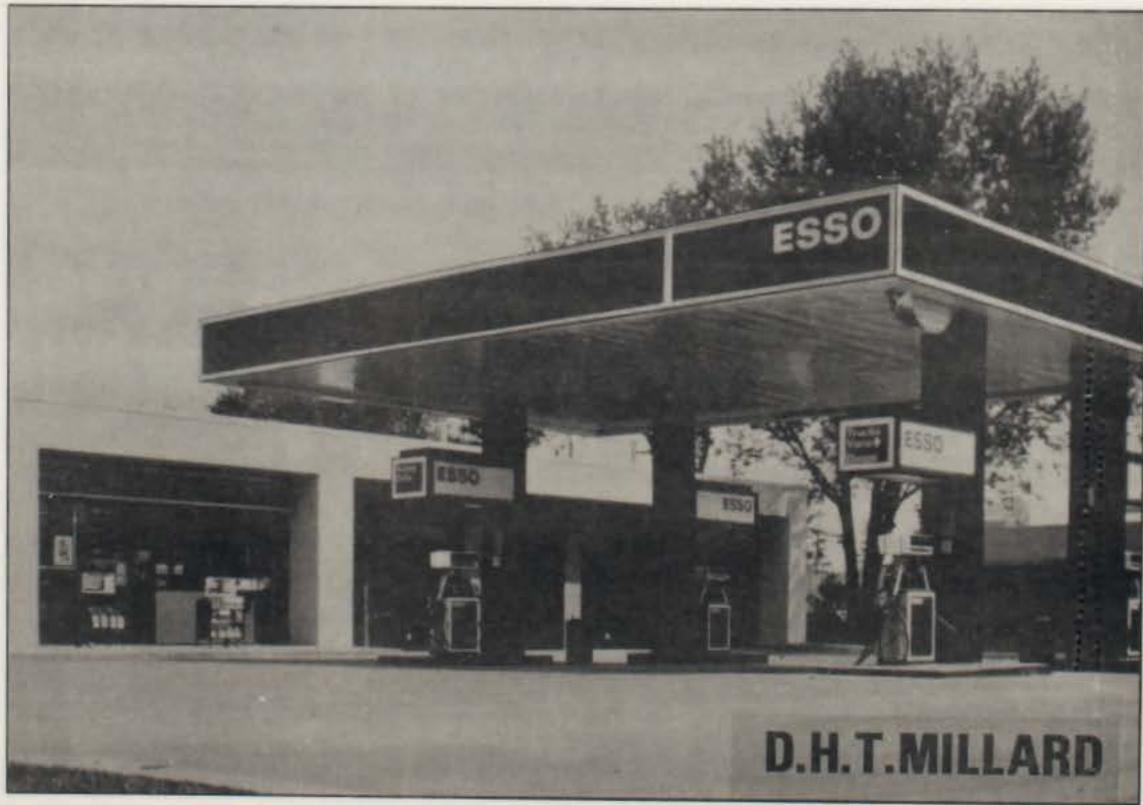


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Canada

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1.0 SUMMARY

Encompassing the period from 1930 through 1985 this document describes the significant changes in formulation of Imperial's engine oils and the reasons for those changes. The history is mainly limited to gasoline and diesel engine oils for automobiles and commercial ground transportation with a small section on stationary natural gas engine oils. These applications were the main areas of effort for the Company's Research Department and Technical Services - Marketing Department in the engine oil business.

The introduction outlines the interaction between Company technical personnel and industry contacts whereby the development of oils designed to meet all the market needs, evolved over the years.

The key oil components, basestocks and additives, are also covered together with their sources and some of the processes involved. The evolution of the engine oil quality classifications via government, engine builders and the technical societies (API and SAE) introduces the Automobile Oil section.

Railroad diesel engine oils are covered in some detail since the Company played a key role in this market, culminating in the recent development of fuel efficient formulations.

In conclusion, it is hoped this history will provide new Company technical personnel with a valuable insight into the intricate world of product development and a sense of pride in joining a team that has kept the Company on the leading edge of engine oil technology.

1.1 About the Author

Born in Exeter, England in 1927, the author studied mechanical engineering at a college of London University. After a brief period of military service he joined the British Internal Combustion Engine Research Association (BICERA) as a trainee engineer in 1949. His first project involved the evaluation of high sulphur diesel fuel effects on diesel engine wear. In 1950, he accepted an engineering assistant position with the Anglo Iranian Oil Company (later British Petroleum) at Sunbury Research Laboratories. The author worked on both fuel and lubricant basestock evaluations before emigrating to Canada in 1951. In Canada he obtained a technician position with A.V. Roe (Canada) Ltd working with RCAF approval of the Orenda jet engine for the CF-100 fighter. In June 1952, he accepted a position of technical service engineer with Imperial Oil Limited at Sarnia.

For the next ten years, the author worked as a field engineer, helping to solve customer problems with fuels and lubricants and contributing to the development of new and improved products. This was the decade of the gasoline 'octane race' to satisfy the high compression V8 engines and the introduction of additives to alleviate carburetor icing and spark plug fouling. Multigrade detergent oils also became popular during this time for 'all season' use as oil drain periods were lengthened for passenger cars.

In January 1963, he joined Enjay Chemical Co. Limited as an additives sales representative and, in October of that year became Manager of this small sales operation (owned by Esso International of New York).

In 1967, he moved to Imperial's Chemical Products Department as Additives Division Manager, with additional responsibility for Oilfield Chemicals sales as well as PARAMINS additives manufacturing and marketing across Canada.

In 1979, the author moved to PARAMINS Research Laboratories, Linden, N.J. (ER&B Co.) as Head, International Technical Service with responsibility for PARAMINS technical support to Exxon Chemical Far East, before retiring in December 1982.

However, it would be remiss not to include other contributors to this history who have assisted with suggestions and editing.

The author would particularly like to acknowledge the contributions of A.M. White, G.W. Holmes and R. Overton. Among other contributors were L.R. Carey, W.H. Stover, J. McColm, D.A. Leggett, S.A. Hunter, W.D. Hewson and D.A. Gudelis who initiated the project.

Significant contributors to engine oil development in the period covered include R.K. Stratford, O.S. Pokorny, L.W. Sproule, T.F. Lonstrup, W.S. Pattenden, B.J. Howlett and D.E. Steere. Associated with the field work supporting these efforts in Technical Services - Marketing were Messrs. G. MacIntyre, D.L. McGillivray, J.W. Leach, G.J. Young, A.S. Olver, P.M. Krawchuk, and J.R. Caverhill.

2.0 INTRODUCTION

Since the formation of Imperial Oil's Technical and Research Division in 1928, a group of dedicated oil specialists and scientists has been meeting the lubrication needs of Canada's engines.

Based at Sarnia, Ontario and working closely with Imperial Oil Marketing groups, such as Technical Services - Marketing, engine needs and engine oil formulations to match them have been developed in a cost efficient manner by the Research Department for over 50 years.

The process of matching lubrication needs with oil formulations has evolved as a co-operative program between Research and Marketing:

1. Discuss new needs with Original Equipment Manufacturers (OEM), customers and additive suppliers.
2. Discuss existing field performance of current oils and equipment with Fleet Accounts/OEM field personnel and develop opportunities for testing experimental oils in existing and new equipment.
3. Review requirements with additive suppliers and solicit new additive packages or components appropriate for the basestocks available.
4. Screen new formulations in laboratory bench and engine tests to (a) meet existing industry test standards, (b) meet any new needs via screening tests the industry can provide or are developed by Research.
5. Review the most promising candidate(s) performance and cost with Company departments involved in its manufacture, packaging and distribution to ensure that no internal obstacles to timely commercialization will exist.
6. Select one or more promising cost efficient candidates, that show the improved performance desired, and if appropriate, initiate a closely controlled field test program.
7. Review final candidate performance with OEM/Fleet Accounts, if considered desirable, to facilitate ready market acceptance of the improved product. However, this part of the process must be handled very carefully to avoid the new formulation being blamed for existing equipment problems that are occurring simultaneously or may be aggravated by the improved formulation.
8. Develop the appropriate specifications for the product and components as well as any special blending procedures required. Monitor initial plant production as well as field performance to ensure the desired quality is being met. Deal appropriately with any deviations from expected performance.

9. Throughout this development process, a key role is played by the appropriate Technical Planning Group (TPG). (for example, the Automotive Oil TPG in reviewing all facets of new product introduction and ensuring that objectives are met on time and within cost limits.

The format chosen for this history is to cover specific groups of engine oils by describing their environment and then focussing on individual major brands of oil within each group to cover the key formulation changes that occurred in response to the environment.

There are, in addition, some highly specialized types of engine oil which do not form a significant share of the overall market. These include Aviation and Marine Oils. Imperial has participated successfully in these markets using products and technology obtained from Exxon (earlier Standard Oil of New Jersey) and Mobil (earlier Socony Vacuum Oil Company). It is not proposed to cover the history of these engine oils since they were developed elsewhere.

These are the types of engine oil that will be included:

- I. Automotive Oils - Gasoline and Diesel
- II. Railroad Oils - primarily Diesel
- III. Industrial/Stationary Engine Oils - Diesel and Natural Gas

The emphasis will be on Esso/Imperial branded products although Research and Technical Service efforts also support the wholesale 'supply sales' market. This includes sales to OEM's (factory and service fill) and to rebranders and retail accounts. This forms 25-30% of Imperial's engine oil business and often requires the development of special formulations or modifications to existing Esso branded products to meet customer requirements.

Although there will be some comments in the environments covering the period prior to World War II, the main focus will be on the post War period. The reason for this is that earlier research was largely concerned with basestock processing to improve quality, yield and crude flexibility. This was to avoid having to use only a few crude oils which provided acceptable quality stocks via simple distillation and clay filtration.

Reference will be made to basestock processing advances such as Phenol Treating (Solvent Refining), Hydrofining and Hydrocracking as they become pertinent in the text.

Since additives are a significant factor in the performance of modern engine oils in terms of keeping the engine clean and protected against wear and corrosion, this introduction will proceed with a brief description of additive types and their applications in engine oils.

2.1 Main Additive Types and Uses

POUR DEPRESSANTS (PD) Copolymers of various types which precipitate with and modify the wax crystals which come out of solution when oils are cooled. This allows the oil to flow at temperatures well below its previous solidification temperature (or natural pour point). First developed by Standard Oil Development Company in 1931 as PARAFLOW. Dosage is usually less than 1% in oil. Some viscosity improvers also have intrinsic pour depressancy. Pour depressants are also referred to as lube oil flow improvers (LOFI's).

VISCOSITY IMPROVERS (VI) High molecular weight polymers which improve the viscosity/temperature relationship of an oil by retaining a higher viscosity when heated than would otherwise occur - to reduce wear and oil consumption. They also allow the use of lower viscosity basestocks thus improving fuel consumption at lower crankcase oil temperatures during the warm-up period. 'All Season' oils are the result. Viscosity Improvers first developed by Standard Oil Development Company in 1936 as PARATONE (Polybutylene). Ethylene-propylene copolymers, polymethacrylates and styrene-isoprene copolymers are typical of current products. Viscosity improvers are also referred to as Viscosity Index Improvers and Viscosity modifiers.

DETERGENT INHIBITORS (DI) Neutral, basic and overbased metal salts of various acids which help prevent the formation of high temperature deposits primarily and also disperse sludge deposits to some degree. These metal salts include (a) sulphonates, (b) phenates, (c) phosphonates and (d) salicylates. Types (a) and (b) have been most popular and are the main ones today.

Calcium, magnesium and barium in that order have been the primary metals involved. Alkalinity of the early detergents was in the range of 0-30 total base number (TBN) but discovery of overbasing techniques in the early 1950's allowed production of 300-400 TBN products by the 1960's. These products became very important in diesel engine lubrication by virtue of their fuel sulphur neutralizing abilities which reduced the formation of varnish and carbon deposits in the piston ring zone.

(a) **Sulphonates** are produced by sulphurizing petroleum feedstocks or synthetic feedstocks such as detergent alkylate to make sulphonic acid which is then neutralized by adding alkaline metal oxides or hydroxides. Neutral or low alkalinity (low TBN) products with a high sulphonate 'soap' content (40%) result. These products are good surfactants and possess detergent/antirust properties by virtue of their coating abilities on metal surfaces and some alkalinity. By adding more metal hydroxide and blowing with CO₂ at temperatures high enough for chemical reaction, overbased products result with lower 'soap' content (15-30%). These products provide cost efficient rust protection and fuel sulphur neutralization. Overbased magnesium sulphonate provides excellent engine oil antirust performance, with overbased calcium sulphonate a close second.

- (b) **Phenates** are produced from alkyl-phenol feedstocks, sulphurized and overbased in the same general way. They are not as efficient in rust protection or neutralization as the sulphonates but provide antioxidant properties and high temperature stability to the oil in severe service, as well as diesel deposit control in the piston area.
- (c) **Phosphonates** were made by phosphorus pentasulphide treating of low molecular weight polybutene followed by metal overbasing. When developed, about 1950, barium was the metal of choice but this became progressively less cost efficient than overbased sulphonates/phenates made with calcium or magnesium because the maximum TBN was only about 160 versus 250-400 for phenates and sulphonates. Phosphonates were essentially phased out by the early 1970's, when barium itself was in short supply and prohibitively expensive.
- (d) **Salicylates** were commercialized by Shell and have been primarily used by that company. They are similar to phenates in performance, but superior in silver bearing lubrication, so found some application in EMD railroad oils produced by other oil companies.

Dispersants. This designation is now used by the oil/additive industries to cover various organic polymer types which possess highly polar properties allowing them to disperse engine sludge in a finely divided form. By preventing its deposition in critical areas such as the ring zone and narrow oil passages, the need for frequent (500-1000 mile) oil drains was alleviated by 1960. During the 1950-1960 decade, extensive research by Rohm & Haas, Lubrizol and major oil companies resulted in the commercialization of many ashless dispersant products. Some of these were treated with boron as a finishing step to provide improved anti-corrosion and high temperature detyrancy properties. The usual manufacturing approach was to attach a polar functional group to an oil soluble polymer.

For example, N-Vinyl Pyrrolidone was copolymerized with alkyl methacrylate to produce dispersant viscosity improvers, polybutene was treated with maleic anhydride to make polyisobutylene succinic anhydride then neutralized with polyamines such as tetraethylene pentamine to make succinimide dispersants. These cost efficient products possess several times the sludge handling ability of the metal detergents and have become important even in high temperature diesel service by their ability to keep sludge and varnish precursors in suspension. By the 1970's, ashless dispersants had become the major component of detergent inhibitor packages with up to 8 volume % used in the oil.

Other Inhibitors

Inhibition of oil oxidation, bearing corrosion and wear of highly loaded engine parts has been obtained from phosphorus/sulphur compounds such as ZDDP (zinc dialkylthiophosphate). ZDDP dates back to 1941 as an antioxidant and bearing corrosion inhibitor. It functions as an antioxidant by decomposing hydroperoxides and scavenging radicals, it also forms protective phosphide coatings on non-ferrous bearing metals. Its use as an antiwear agent was defined by General Motors in the early 1950's with the

advent of highly loaded valve trains in overhead valve V8 engines starting with the Oldsmobile Rocket V8 in 1949. Almost all service station oils on the market today around the world probably contain a minimum of 0.5 vol% ZDDP with at least 1% in most high quality oils. Zinc diaryldithiophosphate is a less potent but more thermally stable product used in turbocharged diesel oils.

Other Bearing Corrosion Inhibitors include organic phosphites, dithiocarbamates, sulphurized terpenes and phosphosulphurized terpenes such as P_2S_5 treated α -pinene; these are also antioxidants.

Antioxidants also include hindered phenols and phenyl naphthylamines, sulphides and phenates. Copper compounds are currently being used commercially by Exxon Chemicals PARAMINS Department. These were developed by Exxon Research's Products Research Division.

Rust Inhibitors also include alkenylsuccinic acids and derivatives plus many other compounds with amine phosphite or imidazoline groups. These are used as supplements to the alkaline detergents/dispersants, which provide most of the antirust performance.

Anti-Foam Agents have been mainly silicones which have to be carefully dispersed in the oil or additive as a finishing step to meet industry or customer foam tendency/stability specifications. They are not soluble and remain as a very fine dispersion.

Friction Modifiers such as oleic acid based compounds and others have become important in recent years for energy conserving oils providing up to 3% fuel savings.

Additives play a major role in engine oil performance, and together with modern basestocks, allow the engine designer to keep increasing mechanical and thermal stresses without loss of durability, in the search for greater power and efficiency. Improved basestocks and additives are continually being developed by the oil and additive chemical industries.

Synthetic basestocks are already being used for extreme high and low temperature applications. Ceramic engines, currently being developed for adiabatic (minimum heat loss) combustion, may ultimately use solid or gaseous lubricants.

2.2 Additive Suppliers

Historically, there have been four major suppliers of engine oil additives to the Company:

I. PARAMINS (earlier ENJAY ADDITIVES) from EXXON (earlier Standard Oil of New Jersey)

II. Lubrizol Corp. based in Cleveland, Ohio

III. Chevron Chemical (Oronite Division) from Standard Oil of California

IV. Rohm and Haas based in Philadelphia, Pennsylvania

There has been competition between these suppliers for the engine oil additive business at Imperial which has grown to a value in excess of \$30 million over the years. In 1950, a straight grade passenger car oil like MARVLUBE would contain 3-4% of detergent inhibitor. By 1970, the equivalent brand ESSO EXTRA MOTOR OIL contained a total of 18% (detergent inhibitor + viscosity improver while higher quality oils such as ESSOLUBE XD-3 15W40 contained up to 23%.

The Research Department at Sarnia has been the primary contact with these suppliers working closely with Technical Services - Marketing to ensure that oil performance targets are satisfied with each reformulation.

I. PARAMINS

Prior to 1958, ENJAY ADDITIVES were marketed by Imperial's Refinery Sales Department as a resale product line to the Canadian market.

This was based on the early industry penetration by PARAFLOW dispersants, PARATONE viscosity improvers and PARANOX detergent inhibitors. As competition increased it was found that more marketing and technical focus was needed so that in 1958, ENJAY INC, established a branch office in Toronto. By 1961, this was formed into a wholly owned subsidiary, ENJAY CHEMICAL CO. LIMITED, of ESSO INTERNATIONAL and worked closely with Imperial Oil's Chemical Products Department in developing the Canadian market for PARAMINS additives. In 1965, detergent inhibitor manufacturing facilities were built at Sarnia for barium phosphonate followed by ashless dispersant and viscosity improver manufacturing as well as detergent inhibitor package blending. The Research Department has provided key personnel over the years to work in PARAMINS product and manufacturing technology areas.

Notwithstanding this close working relationship, PARAMINS has not always been able to meet Imperial's quality, timing and cost targets and, while enjoying the major share (~70%) has had shortfalls, particularly in the OEM factory fill, railroad and natural gas engine areas.

Surpass Chemicals Limited of Scarborough, Ontario has been a prime supplier of sulphonates to PARAMINS since the 1960's.

II. Lubrizol Corporation

A wholly owned subsidiary, Lubrizol of Canada Ltd, operates manufacturing facilities in Niagara Falls, Ontario and a sales office is located in Burlington, Ontario. Particularly strong in automotive detergent inhibitors and more recently in viscosity improvers. A leading industry supplier of gear oil and automatic transmission fluid additives. Lubrizol also has extensive engine test facilities near Cleveland, Ohio.

III. Chevron Chemical (Oronite Division)

A wholly owned subsidiary, Chevron Chemical Canada, operates a sales office at Burlington, Ontario. Additive blending is carried out at Surpass Chemicals facilities in Scarborough. Areas of strength include detergent inhibitors for heavy duty applications particularly turbocharged diesel and

natural gas engines. Oronite is the largest supplier of railroad diesel oil detergent inhibitors and has extensive engine test facilities at Richmond, California. Oronite is also the largest supplier of 2-cycle outboard engine oil ashless detergent inhibitors.

IV. Rohm & Haas (Acryloid Additives)

A wholly owned subsidiary, Rohm & Haas Canada Ltd, operates manufacturing facilities at Morrisburg, Ontario for the production of methacrylate viscosity improver and pour depressants. This business is an offshoot of the main acrylic resin business. R&H has been a major supplier of viscosity improvers + pour depressants over the years. PARAMINS has resold R&H products to Imperial on occasion so as to retain control of the affiliate viscosity improver market until a suitable product could be manufactured 'in house'. R&H has tried to expand into the detergent inhibitor area periodically but without lasting success in either engine oils or automatic transmission fluids.

Other Additive Suppliers

Monsanto, Amoco and Edwin Cooper have all tried to penetrate the Company's additive business without much success since 1950. Lack of technology or local manufacturing facilities with attendant supply and economic disadvantages have been their primary problems.

2.3 Basestocks 1890-1986

Initially, heavy distillates obtained at high temperature from selected crude oils were the first mineral lubricating oils and displaced the animal fat oils used previously. The high temperatures caused undesirable cracked residues in these early lubricating oils. These were removed by treatment with sulphuric acid and air blowing which precipitated the asphaltenes into the acid. The acid sludge was drained and the oil was washed with lye to neutralize trace acid remaining, before chilling and wax removal by filtration. The dewaxed oil was again acid and lye washed before a portion was filtered through clay or fuller's earth to produce pale yellow oils of high quality known as pale oils.

By 1910, steam distillation was used to avoid the high temperature asphaltene problem using crudes selected primarily for lube production. In this process, the primary distillation was run at a lower temperature and avoided cracked residues. These steam distilled fractions did not require significant acid treatment and were known as neutrals. The high lube quality Pennsylvania crudes contained no asphalt and also no asphaltenes were created during processing so these neutrals were not acid treated and merely required filtration to improve/lighten their colour. This minimal processing caused Pennsylvania lubes to acquire a performance mystique which endured for many years. The residue in the steam still was a waxy high viscosity residual oil that could be processed into steam refined stock and bright stock.

The coastal crudes of Texas and California and some South American crudes were naphthenic and asphaltic in character. They produced relatively wax free oils excellent for low temperature lubrication. However, their viscosity temperature relationship was poor in that they 'thinned out' rapidly at temperatures above 100°F (40°C).

The paraffinic crudes inland in North America were waxy and had good viscosity temperature characteristics, later called high Viscosity Index on a scale of 0 to 100. A high VI oil was 80 or better, medium VI around 60-75 and low VI around 30.

By 1920, vacuum distillation was being pioneered at Sarnia to increase the yield of asphalt free lube fractions but there was still a need to produce good low temperature oils with high VI for gasoline engines. By 1930, Imperial Research had developed and commercialized the phenol solvent treating process at Sarnia Refinery. This removed undesirable aromatic compounds and improved the VI of naphthenic stocks from 30 to 75. Medium VI paraffinic stocks were improved from 70 to 100 and 90-95 became the normal VI for production of mid-continent lubes. By 1936, use of viscosity improvers such as PARATONE allowed the production of 130+ VI oils known as multigrade, multiviscosity or All Season oils. These did not become a significant factor in the marketplace until after 1955 when the car manufacturers started to increase recommended oil drain intervals. This allowed oil companies to promote All Season oils with better low temperature startability and reduced fuel consumption during warm-up.

There was still a desire to utilize the heavier high VI paraffinic oils year round but winter performance was limited by their wax content and high pour points (60°F). Imperial Research developed a very efficient solvent dewaxing process in 1938 using methyl, butyl and propyl ketones which allowed the utilization of previously unusable paraffinic lube stocks.

Three charts at the end of this section show 1943-46 processing for lubricating oil stocks at Sarnia Refinery incorporating technology previously discussed.

With the discovery of major oil fields in Western Canada starting with Leduc in 1947, Western Canadian crudes were processed for lube oil production at Sarnia. Mid-Continent Louden crude (Illinois) was replaced by Leduc and MCL stocks became MCT (mid-continent type). Later other Western Canadian crudes were used at Sarnia and the new (1955) Edmonton lube plant. Edmonton became the first location to use the new Imperial Research Hydrofining Process for lubricating oils, replacing clay contacting as a finishing step for waxes, turbine oils, transformer oils and premium lubricating oils.

Hydrofining was a hydrogen treating process developed by Esso Research and Engineering Company for naphthas and fuel distillates. It followed the earlier Hydrocracking process commercialized at Baton Rouge in 1930 by Standard Oil Development Company which was ahead of its time. More recently, Hydrocracking has been used in the production of high VI lube basestocks by Gulf Canada among others, and is also widely used for upgrading residual fuels into lighter petroleum fractions of higher value.

By 1971, the basestock treating of Sarnia and Montreal distillates had developed as shown in the two flow charts dated August 1971. Hydrofining had replaced acid and clay treating completely. Current processing at Sarnia and Strathcona (1982 charts) show further simplifications in the processing and product slate. NMP extraction has replaced phenol extraction at Strathcona. LCT naphthenic distillates, with the exception of Venezuelan imported CWO distillate, used for electrical and low temperature hydraulic oils, are no longer processed having been replaced by MCT stocks in most applications (e.g. LCT 40 by MCT 30/MCT 60 in railroad oil).

SIGNIFICANCE OF BASESTOCK QUALITY

Although additives play a major role in providing engine oil performance, basestocks are also significant contributors. Their quality is a key factor in defining engine oil viscometric properties at both high and low temperatures. Basestock volatility is also critical in controlling oil consumption. More recently, the development of composition related basestock quality criteria (Performance Indices) has greatly simplified the selection of new crudes and processes for basestock and engine oil manufacture. However, it is still important to remember that any changes in basestock manufacture can impact on engine oil performance and should be thoroughly checked out.

The ability to categorize basestocks based on compositional criteria to provide Performance Indices was developed by Imperial's Research Department at Sarnia during the 1970's. These also allow the oil formulator to match basestock and additive performance more closely for improved cost efficiency and improved engine performance in meeting oil quality targets.

COLOMBIAN WEBSTER CRUDE 1943
COLOMBIAN - WEBSTER DISTILLATES - MONTREAL

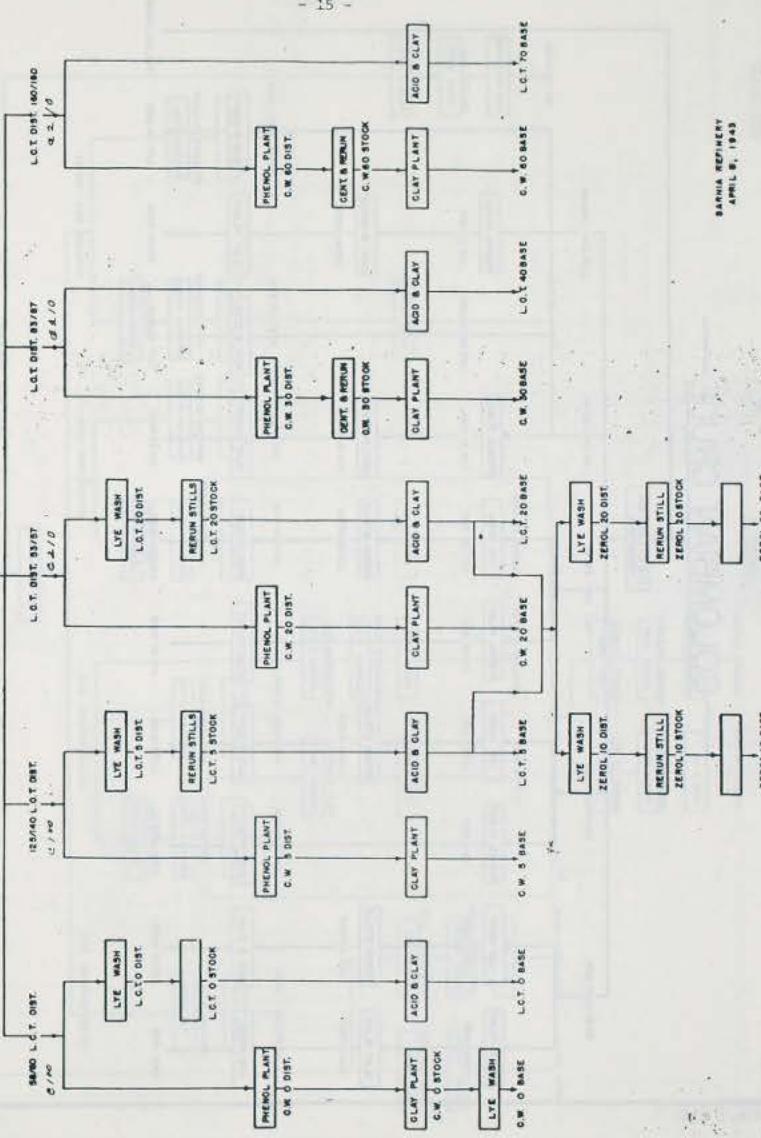
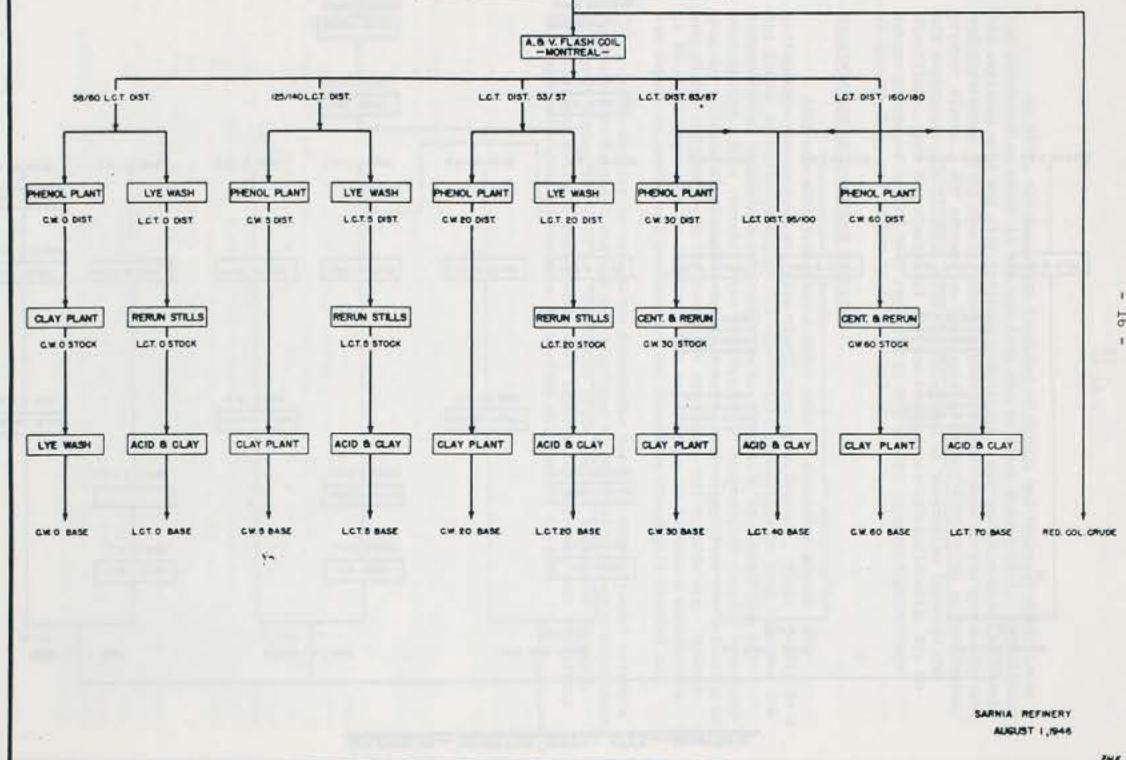


CHART 2

— COLOMBIAN CRUDE —



SARNIA REFINERY
AUGUST 1, 1946

CHART 3
MID-CONTINENT- LOUDEN CRUDE : 1943

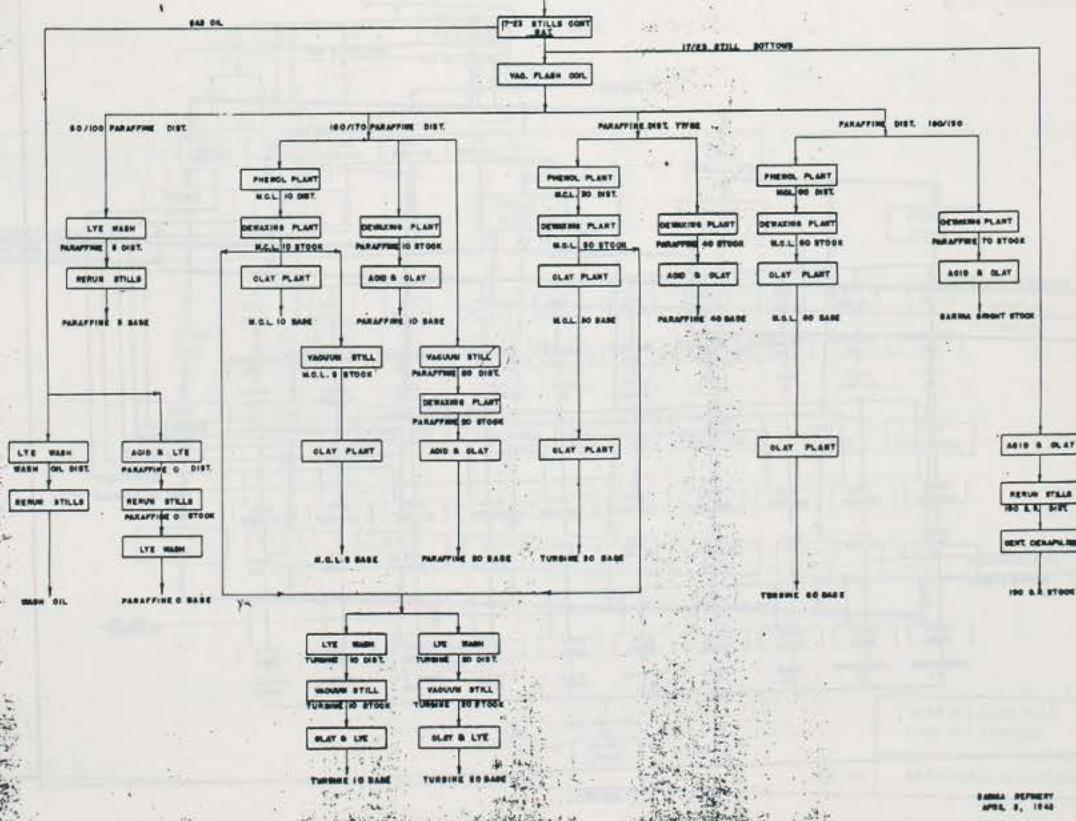


CHART 4

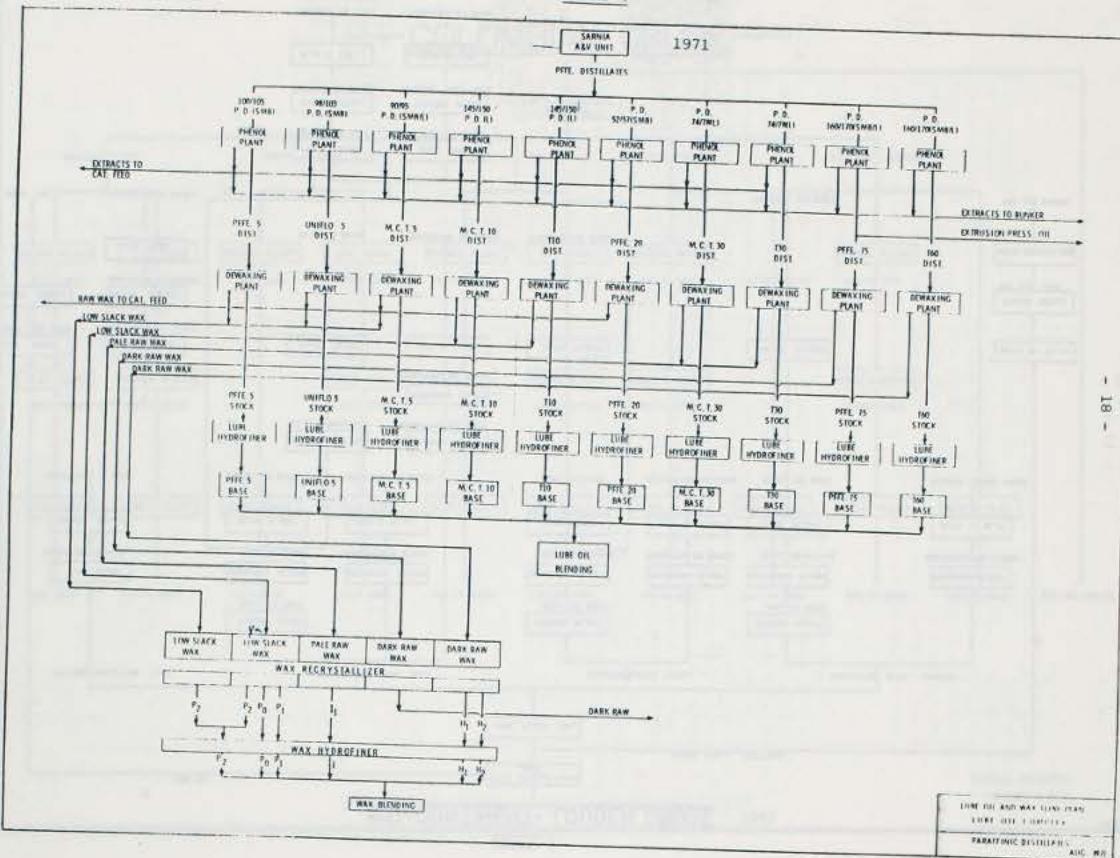


CHART 5

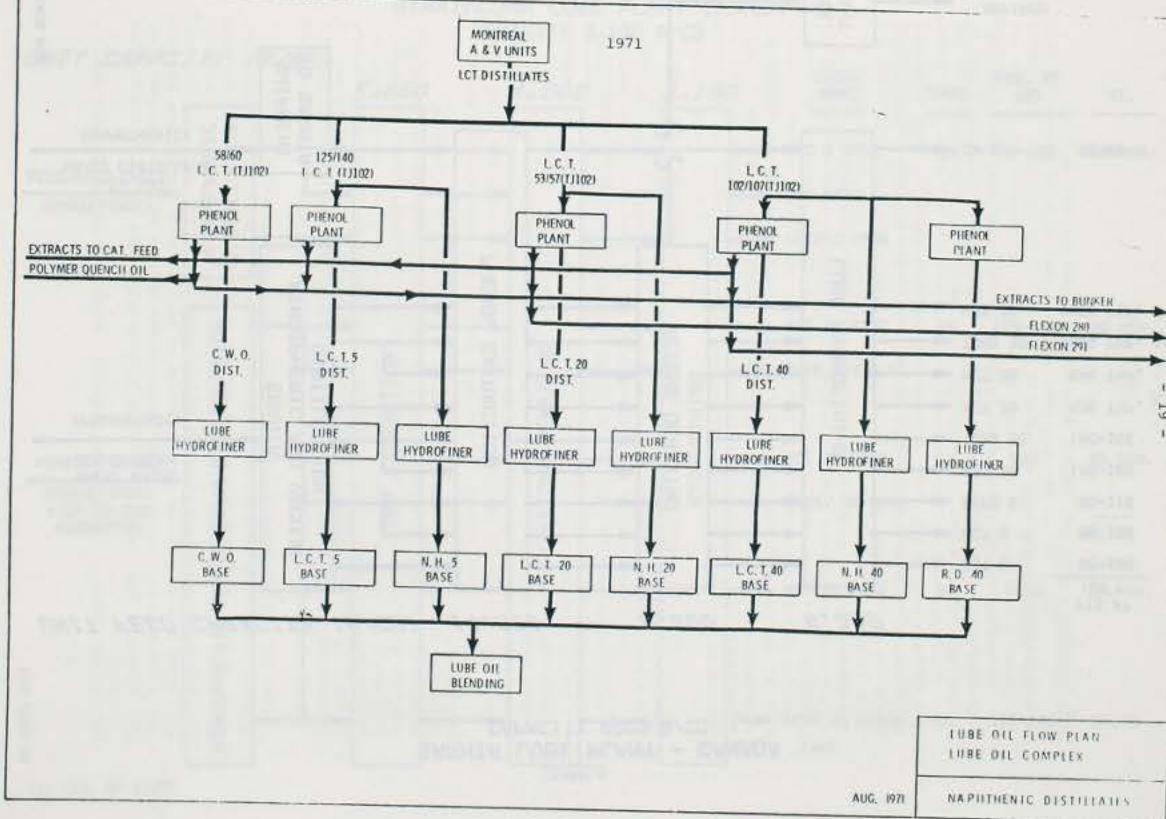


CHART 6
SARNIA LUBE PLANT - CANADA 1982
CAPACITY 6000 B/CD

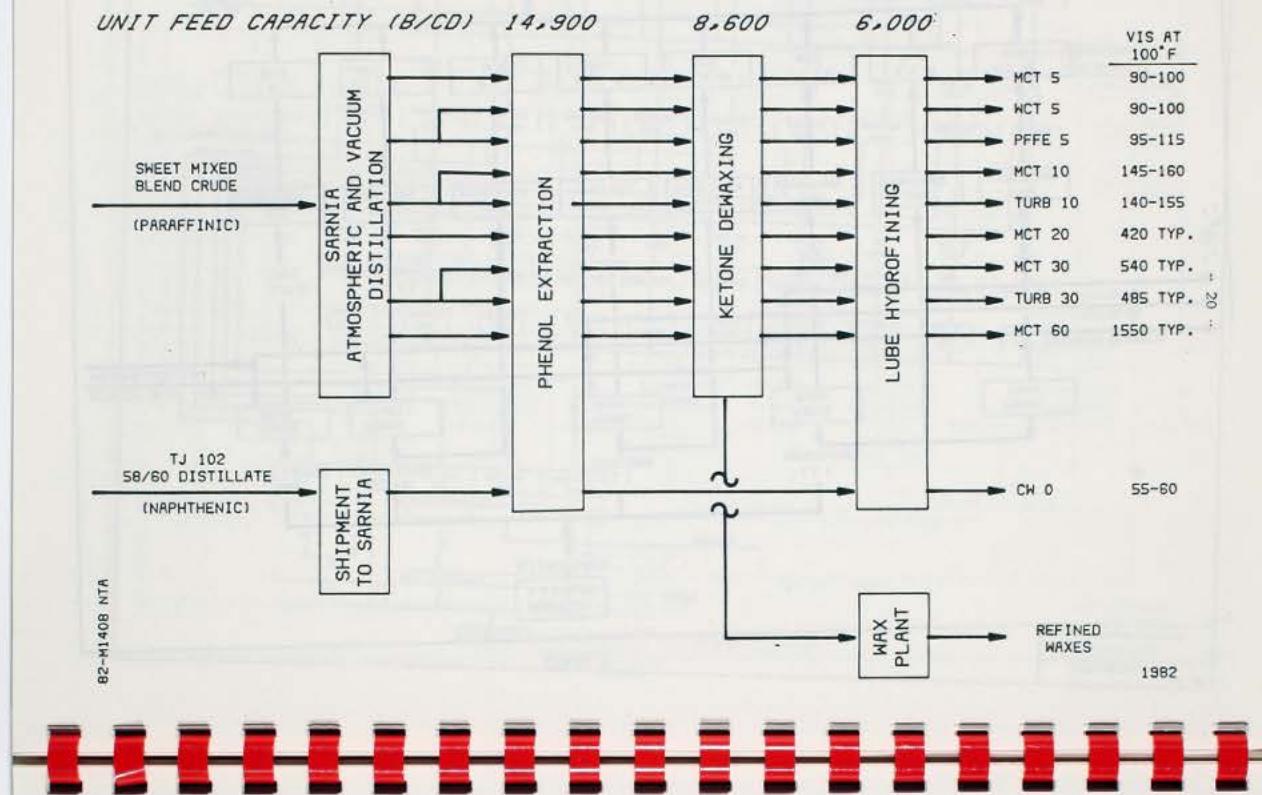
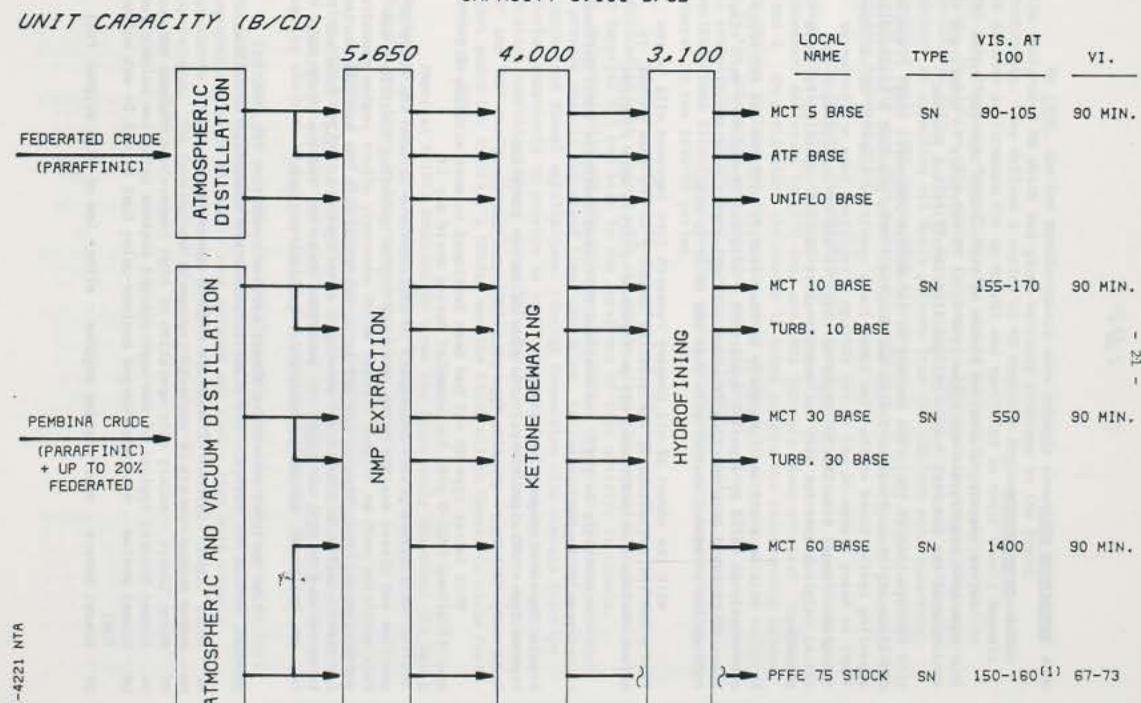


CHART 7
STRATHCONA LUBE PLANT-CANADA 1982
CAPACITY 3,100 B/CD



(1) VIS. AT 210°F

3.0 AUTOMOTIVE OILS

3.1 INTRODUCTION

Before starting a detailed review of the various Imperial engine oils that have been significant since the 1930's, it is necessary to understand the evolution of the industry Engine Oil Quality Classification systems.

Starting in 1911, the Society of Automotive Engineers (SAE) Crankcase Oil Viscosity Classification System was adopted. This provided a standardized measuring system based on the time taken for a specified quantity of various light to heavy grades of oil to run through a capillary tube or viscometer. The grades ranged from SAE 10 (light or thin) to SAE 60 (heavy) with the latter only suitable for very hot weather as it was far too thick for cold starting.

Oils were drained frequently as they readily oxidized and thickened excessively as noted by dipstick appearance. Seasonal changeovers were also required to avoid cold starting problems with thick oils or high oil consumption in warmer weather with thin SAE 10 or 20 oils.

With the advent of oil company research into improved oils in the 1930's and the beginnings of the additive industry in the same period, it became obvious that additional oil performance criteria were required.

Accordingly in 1947, the American Petroleum Institute (API) defined three types of Engine Oils:

Regular Type - Straight mineral oils

Premium Type - Straight mineral oils plus oxidation inhibitor

Heavy Duty (HD) Type - Premium Type plus detergent additives

This latter type HD oil had been developed to meet military oil specifications (MIL-O-2104 for example) during World War II.

This system proved inadequate to differentiate between the needs of gasoline and diesel engines or to recognize engine operating conditions and fuel qualities such as sulphur content which adversely affect engine deposits and operation. Accordingly, the API in co-operation with the American Society for Testing and Materials (ASTM) developed a new system in 1952. This was later revised in 1955 and 1960. It described three oil service conditions (ML, MM, MS) light, medium and severe for gasoline engines.

Also included were three diesel service conditions (DG, DM, DS) general, medium and severe. The classifications are summarized as follows:

ML - Motor Light - typical of moderate highway operation

MM - Motor Medium - a mix of highway/city operation

MS - Motor Severe - mainly city operation or high temperature highway use

DG - Diesel General - typical of non-supercharged engines using low sulphur fuel

DM - Diesel Medium - non-supercharged engines using fuel with 0.5+ wt% sulphur fuel

DS - Diesel Severe - supercharged engines - either low or high sulphur fuel

By 1958, the Car Manufacturers were unhappy about the quality of some oils designated MS which had given warranty problems in the field. Accordingly, they defined a series of MS Sequence Engine Tests to establish the minimum performance for an MS oil and specified in their Owners Manuals that only "Sequence Tested" MS oils should be used for the warranty to be valid. To tighten this system further, in 1964 Ford issued specification M2C-101A to define a 1964 MS Warranty Approved Oil. Ford was leading the industry in extending oil drain periods from the 500-1000 mile intervals specified until 1960, up to 4000 mile drains in 1964, and further to 6000 mile drains in 1968 when Ford Specification M2C-101B was issued to define MS (1968) Warranty Approved Oil.

By 1969-70, the API/ASTM/SAE issued an entirely new classification system defining eight categories of engine oil. This system and its subsequent additions in 1970 (SE) and 1981 (SF) are shown overleaf, in Tables 1 and 2. In particular, the reader is asked to note the relationship between the various systems and the engine tests which apply as these will be referred to in the subsequent text covering each oil brand. Since 1958, the crankcase oil industry has mainly been responding to industry needs by meeting OEM specifications rather than leading engine development with improved oils, as occurred in the 1930-55 period.

However, certain oil companies and additive manufacturers have continued to work closely with the OEM in pioneering new high performance oils and Imperial Oil has been in the forefront of this activity in Canada, e.g. Universal Oils and Energy Conserving Oils. Universal Oils are designed to provide one oil for mixed fleet operation, including both gasoline and turbocharged diesel applications. Energy Conserving oils contain friction reducing components to provide up to 3% improved fuel economy under certain operating conditions where engine friction is at a maximum. There have been "SE" and "SF" energy conserving oils at most oil company service stations in recent years but Imperial's UNIPLO was the first oil in Canada to claim fuel economy in 1978.

Imperial's 1972 ESSOLUBE XD-3 was the first truly Universal Oil being "SE-CD" and suitable for Detroit Diesel 2-cycle engines for which a 1% maximum sulphated ash level in the crankcase oil was specified.

Tables 1 and 2 indicate how the quality levels of gasoline and diesel engine oils have been progressively raised over the years by adding both more and more severe, engine test requirements. Currently the industry is close to adopting the next higher levels, SG for gasoline and CE for diesel.

Tables 3-5 describe the SAE Viscosity Classification system in both 1950, 1968 and current versions. It can be seen that there has been a logical progression towards viscosity test methods and limits that more closely approximate engine oil operating conditions at both low and high temperatures. The development of a new high shear/high temperature method is close to completion.

TABLE 1
API ENGINE SERVICE CLASSIFICATION AND EQUIVALENT SPECIFICATIONS

API ENGINE SERVICE CLASSIFICATION			RELATED MILITARY/INDUSTRY SPECIFICATIONS				
Current (1969 -)	Obsolete (1952-68)		U.S. Ordnance	Canadian Government	Industry		
Gasoline	Diesel						
SA	-	ML	-	-	-	-	
SB	-	MM	-	-	-	-	
SC	-	MS (1964-67)	-	-	Ford M2C101A GM 4745M		
SD	-	MS (1968-71)	-	-	Ford M2C101B GM 6041M		
SE (1972-80)	-	-	-	-	Ford M2C101C M2C144A M2C153A GM 6136M		
SF (1981-)	-	-	-	-	Ford M2C153B GM 6048M		
-	CA	DG	MIL-L-2104A	-	-		
-	CB	-	MIL-L-2104A(SUP I)	-	-		
-	CC	DM	MIL-L-2104B	-	-		
-	CD	DS	MIL-L-45199B	-	Caterpillar Series 3		
SD	CC	-	-	-	GM 6042M IHC #1 Gasoline		
SE	CC	-	MIL-L-46152 MIL-L-46152a	3-GP-302M	GM 6146M		
SF	CC	-	MIL-L-46152b	3-GP-302M a	GM 6049M		
SD	CD	-	MIL-L-2104C	3-GP-304M	-		
SE	CD	-	-	-	Mack EO-H EO-J IHC #1 Diesel		
-	-	-	-	-	Mack EO-K EO-K/2		
SF	CD	-	MIL-L-2104D	-	Cummins NTC 400		

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TABLE 2
API ENGINE SERVICE CLASSIFICATION - Engine Tests Required

Engine Tests	Gasoline										Diesel			
	SA	SB	SC	SD	SE	SF	CA	CB	CC	CD				
C -L-38 Bearing weight loss mg max	-	500	50	40	40	40	50	50	50	50				
Oldsmobile Sequence II (low temp. series)	-	-	IIA	IIB	IIC	IID	-	-	IID	-				
Rust Merit (10-clean) minimum	-	-	8.2	8.8	8.4	8.5	-	-	7.7	-				
Oldsmobile Sequence III (high temp. series)	-	-	IIIA	IIIB	IIIC	IID	-	-	-	-				
Sludge Merit (10-clean) minimum	-	-	9.5	9.6	9.0	9.2	-	-	-	-				
Piston Skirt Varnish Merit minimum	-	-	9.7	9.6	9.3	9.2	-	-	-	-				
Oil Ring Land Varnish Merit Minimum	-	-	-	-	6.0	4.8	-	-	-	-				
Hydraulic Valve Lifter Scuffing	-	-	N11	N11	N11	N11	-	-	-	-				
Camshaft Lobe Wear Av-in ⁻⁴ max	-	-	25	30	10	40	-	-	-	-				
Max-in ⁻⁴ max	-	-	-	-	20	80	-	-	-	-				
Oil Viscosity Increase % max at 40 hrs	-	-	-	-	400	-	-	-	-	-				
% max at 64 hrs	-	-	-	-	-	375	-	-	-	-				
Chrysler Sequence IV (high temperature)	-	N11	N11	N11	-	-	-	-	-	-				
Cam Scuffing	-	2	2	1	-	-	-	-	-	-				
No. of lifters scuffed - max.	-	-	-	-	-	-	-	-	-	-				
Ford Sequence V (low/high temp.)	-	-	V	VB	VC	VD	-	-	-	-				
Sludge Merit (50 or 10-clean) - min.	-	-	40	42.5	8.5	9.4	-	-	-	-				
Varnish Merit () - min.	-	-	35	37.5	8.0	6.6	-	-	-	-				
Piston Skirt Varnish Merit (10-clean) - min.	-	-	7.0	8.0	7.9	6.7	-	-	-	-				
Cam Lobe Wear Av-in ⁻⁴ max.	-	-	-	-	-	10	-	-	-	-				
Max-in ⁻⁴ max.	-	-	-	-	-	25	-	-	-	-				
Ford Falcon Rust (10-clean) min.	-	-	-	9.0	-	-	-	-	-	-				
CRC Low Temp. Deposition (LTD)	-	-	-	-	-	-	-	-	42	-				
Sludge Merit (50-clean) - min.	-	-	-	-	-	-	-	-	42	-				
Varnish Merit (50-clean) - min.	-	-	-	-	-	-	-	-	7.5	-				
Piston Skirt Varnish (10-clean) - min.	-	-	-	-	-	-	-	-	-	-				
Caterpillar Single Cylinder Diesel	-	-	-	-	-	-	25	-	-	-				
L-1 (0.35% sulphur fuel) Top Groove Fill % max.	-	-	25	25	-	-	-	25	-	-				
L-1 (0.95% sulphur fuel) Top Groove Fill % max.	-	-	-	-	-	-	-	-	30	-				
1-H ^X (0.35% sulphur fuel) Top Groove Fill % max.	-	-	-	-	-	-	-	-	45	-				
1-2 ^X (0.35% sulphur fuel) Top Groove Fill % max.	-	-	-	-	-	-	-	-	-	75				
1-D ^X (0.95% sulphur fuel) Top Groove Fill % max.	-	-	-	-	-	-	-	-	-	60				
1-G ^X (0.35% sulphur fuel) Top Groove Fill % max.	-	-	-	-	-	-	-	-	-	80				
1-G2 ^X (0.35% sulphur fuel) Top Groove Fill % max.	-	-	-	-	-	-	-	-	-	-				

x Turbocharged to various levels. Also additional piston cleanliness requirements.

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TABLE 3

SAE ENGINE OIL VISCOSITY CLASSIFICATION (1950)

SAE Viscosity Grade	Viscosity Range (Saybolt Universal Seconds)			
	at 0°F (extrapolated)		at 210°F	
	Min.	Max.	Min.	Max.
5W		4,000		
10W	6,000 (A)	less than 12,000		
20W	12,000 (B)	48,000		
20			45	less than 58
30			58	less than 70
40			70	less than 85
50			85	110

Note A Minimum viscosity at 0°F can be waived provided viscosity at 210°F is not below 40 SUS

Note B Minimum viscosity at 0°F can be waived provided viscosity at 210°F is not below 45 SUS.

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TABLE 4

SAE ENGINE OIL VISCOSITY CLASSIFICATION SAE J300 (1968)

SAE Viscosity Grade	Viscosity Units (d)	Viscosity Range (C)	
		at 0°F (-17.8°C) Min.	at 210°F (99°C) Max.
5W	CENTIPOISE		less than 1,200
	Saybolt Univ. Secs		less than 6,000
10W	CENTIPOISE	1,200 (a)	less than 2,400
	Saybolt Univ. Secs	6,000	less than 12,000
20W	CENTIPOISE	2,400 (b)	less than 9,600
	Saybolt Univ. Secs	12,000	less than 48,000
20	CENTISTOKES		5.7
	Saybolt Univ. Secs		45
30	CENTISTOKES		9.6
	Saybolt Univ. Secs		58
40	CENTISTOKES		12.9
	Saybolt Univ. Secs		70
50	CENTISTOKES		16.8
	Saybolt Univ. Secs		85

Notes (a) Min. viscosity at 0°F may be waived provided vis. at 210°F is not below 4.2 cSt
 (b) Min. viscosity at 0°F may be waived provided vis. at 210°F is not below 5.7 cSt
 (c) The viscosity of all oils included in this classification shall not be less than 3.9 cSt @ 210°F.
 (d) Official units are Centipoise (cP) and Centistokes (cSt). SUS are shown for information only.

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TABLE 5

SAE ENGINE OIL VISCOSITY CLASSIFICATION SAE J300 (SEPT. 1980)

SAE Viscosity Grade	Viscosity (cP) at Temperature (°C) (1) Max.	Borderline Pumping Temperature (°C) (2)		Viscosity (cST) (3) at 100°C	
		Max.	Min.	Max.	Min.
0W	3,250 at -30°C	-35°C	3.8 cST	5.6	less than 9.3
5W	3,500 at -25	-30	3.8	9.3	less than 12.5
10W	3,500 at -20	-25	4.1	12.5	less than 16.3
15W	3,500 at -15	-20	5.6	16.3	less than 21.9
20W	4,500 at -10	-15	5.6		
25W	6,000 at -5	-10	9.3		
20				5.6	less than 9.3
30				9.3	less than 12.5
40				12.5	less than 16.3
50				16.3	less than 21.9

- (1) Cold cranking simulator viscosities correlate with low temperature engine cranking speeds.
- (2) Measured by ASTM D-3829, low shear method for measuring the oil's ability to flow to the engine oil pump inlet and provide adequate oil pressure during initial engine operation after a cold start. The MRV or Mini Rotary Viscometer is the test instrument.
- (3) Measured by ASTM D 465, a low shear method of measuring engine oil viscosity at normal operating temperatures e.g. 100°C (212°F). A high shear method at 150°C, closer to actual bearing conditions is currently under development with correspondingly lower limits.

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3.2 Early Major Brands (1918-)

POLARINE - Straight Mineral Oil - Medium Quality - general service replaced (1918-1955) by Mineralube in 1955.

MARVELUBE - Initially, high quality mineral oil for automotive and farm service
(1933-63) - later a detergent oil

IMPERIAL RPM DELO - A popular medium duty diesel oil manufactured under licence (1941-81) from Standard Oil of California

IMPERIAL ESSOLUBE HD - A detergent oil developed during WWII (1941-)

IMPERIAL ESSOLUBE SDX - A highly detergent oil for Caterpillar supercharged (1949-56) diesel engines replaced by ESSOLUBE D-3 in 1956

Due to a lack of documentation for the early years, the author was not able to provide detailed formulation data for this period.

Available data are summarized in the following pages.

3.2.1 POLARINE and MINERALUBE

A medium viscosity index straight mineral oil (60 VI) for general service, available in SAE grades 10 through 60.

It is referred to in the 1922 Lubrication Manual and was established some years earlier.

1934 POLARINE Oil Light Medium

41% #200 Filtered Zero Pale Oil/58.8% #100 FZPO/0.5% Conc. Bloom Saybolt Universal Seconds (SUS) Viscosity at 0°F 10,000 max.
130°F 73-75

Pour Point °F -25 max. Meets tentative SAE 10W specifications.

1936 POLARINE 10W - formula as above.

1942 POLARINE 10W

37.4% MCL-10/29% #550 Stock/32.9% #554 Stock/0.6% #190 SR Stock 0.1% PARAFLOW Pour Depressant

SUS at 0°F 10,000 max. 60 VI min.
210°F 41.5 min. Pour -35°F max.

1951 POLARINE 10W

49.75% LCT-5/25% CW-5/25% CW-20/0.1% PARAPLOW/0.15% Stock 3900
Specifications as for 1942.

POLARINE was cancelled and replaced with the 90 VI brand MINERALUBE about 1955.

MINERALUBE manufactured from MCT basestocks and later fortified with zinc dialkyldithiophosphate (ZDDP) at 0.5 vol% continued to be marketed in the SAE 10W, 20 and 30 grades. It is still available today for those applications where an oxidation and antiwear inhibited straight mineral oil is recommended.

3.2.2 MARVELUBE 1933-63

Initially, a high quality straight mineral oil when introduced in 1933 in 'Twenty' and 'Thirty' grades. In 1948, when the SAE 5W grade was established, it became a detergent motor oil for automotive engines.

July 1933 MARVELUBE "TWENTY"

Reduced LCT Colombian Crude, Flashed, Phenol Treated and Vacuum Distilled.

PARAPLOW added if necessary to meet Pour Point
SUS at 0°F 40,000 max. VI 70 min.
210°F 50-52 Pour -20°F max.
Met tentative SAB 20-20W specs.

September 1935

62.5% MARVELUBE 20 Colombian Basestock/35% Special Paraffinic Oil
2% PARATONE VI Improver/0.5% PARAPLOW
SUS at 0°F 27,000 max. VI 95-100
210°F 51.5-53 Pour -20°F max.

January 1935

Branded MARVELUBE 20.

July 1939

Changed to MC Distillate, Solvent Dewaxed/Phenol Treated Filtral clay finished.

October 1942

50% MCL 10 Base/49.6% MCL 30 Base/0.4% PARAPLOW.

December 1950

42.7% MCL 10 Base/15% CW 20/39% MCL 30 Base/0.3% PARAPLOW plus 3.0% Lubrizol 338 Detergent Inhibitor (DI).
Metals wt% - Calcium 0.041 Zinc - 0.053 Phosphorus - 0.043

SAE 10W grade established.
ZDDP required to alleviate valve train wear in GM overhead valve V8 engines.

September 1948 MARVELUBE 5W

Establish MIL-O-2104 HD level (later MIL-L-2104 by 1952)
Vol% 57.5% MCL Base/28.6% CW O Base/4.75% Petrolia and #1 LCT Bright Stock
4.75% PARATONE Viscosity Improver/4.4% PARANOX 62/0.5% PARAPLOW C-12
SUS at -20°F 13,500 max. VI 130 min.
100°F 130-140 Pour °F -50 max.
210°F 44 typical

November 1950

Alternate DI 4% PARANOX 62 or 4% Lubrizol 3179
3.5% PARANOX 104 or 3.5% Lubrizol 338

1954

DI change to 1.75% Lubrizol (Lz) 612 + 0.6% Lz 1060
This was a Barium Phosphonate formulation

1955

MIL-L-2104A approvals (also 3-GP-345a)
30 grade 1.8% Lz 612 + 0.45% Lz 1360 (Barium 0.27, Zn 0.07, P 0.08)
10W " 2.25% Lz 612 + 0.5% Lz 1360
5W " 1.6% Lz 612 + 0.9% Lz 1360 (non-approved)
5W was CW O and 5 Base with MCT 5 plus 3.5% PARATONE N/1% PP 490/1% Ac 763
10W contained 1.5% PARATONE N/0.7% Acryloid/0.3% PARAPLOW 490

1960 MARVELUBE 30

MIL-L-2104A Amendment I also 3-GP-345a
2 vol% ENJ-566 0.7% Lz 1360
Metals wt% Barium 0.28, Zinc 0.07, Phosphorus 0.09 (Also Barium Phosphonate)

THE MARVELUBE BRAND WAS CANCELLED DECEMBER 1963

3.2.3 IMPERIAL RPM DELO (Established October 1941)

SAE 10 Grade - Colombian Blending Stock 10 + 5% RPM DELO Conc. (DI)

SUS @ 0°F 10,000 max. 77 VI Calcium 0.05-0.06 wt%
210°F 43 min. Pour Point - 35°F max.

December 1942

94.5 vol% MCL 10 Base 5% RPM DELO Conc. 0.5% Paraflow
SUS at 0°F 10,000 max. 95-100 VI
210°F 44 min. Pour -40°F max. Stable Pour -40°F max.
Sulphated Ash (SASH) 0.15% min. Ca 0.05-0.06 wt%
Met U.S. Army 2-104B; DND #345; CGPSC 3-GP-19 also Caterpillar and GM
Acceptance Tests.

June 1947

Met U.S. Army 2-104B Amendment #3 (July 1945)
79.5% MCL 10, 16.4 MCL 30, 3.6% RPM DELO Conc. 'F'
0.5% Paraflow Conc. C-12
SASH 0.19-0.23 Ca 0.038 Zn 0.044 Phos 0.038
SUS @ 0°F 13,000 max. 95 VI Pour -40°F
210°F 46 typical

June 1951

Imperial RPM DELO HD 10W (Meets MIL-0-2104)
Contained 4.2 vol% Oronite 1017. Ca 0.075%, Zn 0.042, P 0.040

August 1956

Met MIL-L-2104A 3-GP-345a
95.76% MCT 10 Base 3.54% Oronite 2092 0.7% Paraflow 490
SUS @ 0°F 12,000 max. Pour -35°F max. 90 VI min.
210°F 45 typical Stable Pour -20°F max.
SASH 0.37-0.49 Ca 0.109 Zn 0.039 P 0.036
The 20, 30, 40 and 50 grades contained 3.6 vol% Oronite 2092. Other than a
change in pour depressants, this formulation was unchanged through 1980. It
was cancelled in 1981. It was used primarily as a low ash recommendation for
Detroit Diesel 2 cycle engines to alleviate fire ring (rectangular ring)
sticking. ESSOLUBE HD currently fills this need.

3.2.4 ESSOLUBE HD

Established 1941 as a heavy duty oil for gasoline and diesel
engines. Used MARVELUBE base oil + 2.75 vol% PARANOX 56. SAE 10-50 grades.

U.S. Army 2-104B approval May 1943 plus Caterpillar/GM Acceptance
Tests.

October 1944

Reformulated to 7 vol% Lz-338.
SASH 0.39 Ca 0.07 Zn 0.07 P 0.07 wt%

May 1946

Additive reduction to 4 vol% Lz 738
SASH 0.23 Ca 0.04 Zn 0.04 P 0.04 wt%
Meets 2-104B Amendment #3 and 3-GP-351

August 1947

Reformulated to 3 vol% Lz 338
SASH 0.23 Ca 0.04 Zn 0.055 P 0.043

March 1949

Reformulated to 2.8 vol% PARANOX 104
SASH 0.3 Ca 0.017 P 0.038 Ba 0.148 wt%

July 1951

Reformulated to 3.5 vol% PARANOX 104
SASH 0.38 Ca 0.022 P 0.048 Ba 0.18 wt%
Met MIL-0-2104

The "HD" brand name was cancelled in the 1950's when ESSOLUBE HDX was
introduced. It was reinstated in 1968 using the 1966 ESSOLUBE HDX formulation
as a low ash oil for Detroit Diesel and to alleviate a Cummins oil consumption
problem.

April 1968

Reinstated using 4.15 vol% ECA-1728 (4.4 vol% in 10 grade)
SASH 0.75 Ca 0.15 Ba 0.11 Zn 0.07 P 0.08 N₂ 0.01 wt%
MIL-L-2104B and SC (MS-64) SAE 10 - 50 grades
(1% PARANOX 30 1% C-300 (ECA-4568) 1% PARANOX 351 0.6% PARANOX 15)
(X 300 Total Base Number calcium overbased sulphonate)

June 1972

Reformulated to superior Detroit Diesel oil (in the area of fire ring
sticking) using 4.8% ECA-5112.

This was the excellent "Light Green" field test oil.
SASH 0.95 Ba 0.46 Zn 0.085 P 0.075 N₂ 0.01 wt%

The performance of ECA-5112 rested on the low deposit forming
tendencies and excellent high temperature detergency of barium sulphonate plus
the stability of aryl ZDDP (OLOA 260 or PARANOX 12) at high temperatures in
the Detroit Diesel fire ring zone. This combination gave performance slightly
superior to the calcium phenate/neutral calcium sulphonate/aryl/alkyl ZDDP
formulation from Oronite (4.3 vol% OLOA 1501B) used as an alternate in
ESSOLUBE HD due to Barium Oxide shortages in 1973. This was the start of
severe cost inflation and barium additives were rapidly priced out of any
market where an acceptable calcium formulation existed.

1974

5.8 vol% ECA-7012 (4.8% ECA-5112 + 1% ECA-1140 dispersant)

July 1976

4.3 vol% OLOA-1501B

July 1977

3.6 vol% ECA-7017 (300 TBN Magnesium Sulphonate + Disp/ZDDP)
SASH 0.4 Mg 0.064 Zn 0.105 P 0.095 N₂ 0.03

This very low ash formulation gave excellent DD fire ring performance but proved to be sensitive to glycol coolant contamination leading to bearing corrosion problems.

August 1978

4.3 vol% OLOA-1501B adopted once more and retained pending further field testing of PARAMINS formulations.

September 1983

Reformulated to 4.2 vol% ECA-7085 SC-CC
(C-300, ECA-5025 dispersant, PARANOX 15)
SASH 0.6 Ca 0.125 Zn 0.087 P 0.079 N₂ 0.34 B 0.008 wt%

This is the current formulation, providing excellent Detroit Diesel and bearing corrosion performance.

3.2.5 IMPERIAL ESSOLUBE SDX OIL

Established 1949 in 30 and 10 grades (SAB 20 in August 1951).

October 1949

SAB-10 Caterpillar Series 2 Superior Lubricant
Vol% - 80.5% MCL-10 Base 19% Lz 319 0.5% PARAFLOW C-12
93 VI min. 45 @ 210°F (SUS typical) Pour -35°F max.
SASH 2.8 wt% (Calcium derived)

This brand was replaced as a supercharged diesel oil by ESSOLUBE D-3 in 1956 when the Caterpillar Superior Lubricant Series 3 quality level was established. The corresponding U.S. Military specification was MIL-L-45199 issued in 1958.

3.3 UNIFLO (1963-) - see Table 6

In 1952, the Lubricant Sales section of the Marketing Department requested the development of a 10W-30 detergent engine oil to compete with other multigrade oils appearing on the market. Esso Standard Oil Company had

just introduced ESSO UNIFLO in the US and Socony Mobil was active with Mobiloil Special 10W-30. A formulation, QKS-406A oil, was prepared and costed. It contained 6.5 vol% PARANOX 65, 6.5 vol% Acryloid 763, 0.3 vol% Santolube 394C and 0.5 vol% PARAFLOW 46X. The Pour Point was -50°F, viscosity was 7500 SUS at 0°F and 61 SUS at 210°F for a viscosity index of 145. This project was not supported by the Research Department which argued (in retrospect short-sightedly) that expensive 'all season' oils were not needed since recommended oil drains were typically 500-2000 miles depending on the type of service. Accordingly, the Lube Sales strategy became to promote and resell Mobiloil Special 10W-30 as part of the Mobiloil resale agreement. By 1963, sales of this product were over one million gallons and it became economically attractive to develop an Imperial oil formulation under the UNIFLO brand to enter this high growth market.

The December 1963 UNIFLO 10W-30 was based on the PARANOX 301 (ENJ-566), PARANOX 30 technology (developed for ESSO EXTRA MOTOR OIL) plus ENJ-1125 dispersant (PIBSA/TEPA) and ZDDP. The viscosity improver, PARATONE 440 was a new dispersant type product designed to replace the 430/460 series which had interaction problems with detergent inhibitor components causing haze and gel deposits and viscosity 'drift'. The ash level was quite high at 1.7% and the formulation was too costly relative to Mobiloil Special although it gave superior MS Sequence Test results. PARATONE 440 also proved marginal with respect to detergent inhibitor interaction.

In 1965, a reformulation was made to lower costs and eliminate PARATONE 440 while meeting Ford M2C-101A and GM-4745M Warranty Maintenance Service and also to develop a 5W-30 oil, replacing the original 10W-30 grade. The new 5W30 formulation had outstanding low temperature properties via the Lz-3120 VI which gave minimal 0°F thickening. PARAFLOW 322 was the pour depressant.

The detergent inhibitor was mainly ENJ-1125 dispersant with sufficient ENJ-1038 (C-300) to meet MS Sequence IIA rust requirements and with the ash level lowered to 0.7% by weight. The usual 1% level of PARANOX 15 ZDDP was included (0.8 as such and 0.2 in the ECA-1708 along with ENJ-1038). In 1966, locally produced ECA-1030 (PIBSA/TEPA at Sarnia) dispersant replaced ENJ-1125 but slightly more ENJ-1038 was needed to maintain MS Sequence IIA performance and the ash level rose to 0.9% by weight.

With the advent of M2C-101B/GM-6041M for the API-SD quality level defining 'Warranty Approved' oils for the 1968 model year, yet another reformulation was required. The detergent inhibitor became 9.6 vol% ECA-1751 with the Ford Falcon rust test forcing a doubling of alkalinity reserve to 12 TBN and 1.8% wt% ash. This was optimized to 8.825% ECA-5120 in early 1969 and a 10W-40 grade using Acryloid 726 viscosity improver was introduced. Pour reversion with Ac-726 caused a fast change to ECA-5200 viscosity modifier (OCP) in mid-1969.

PARAMINS obtained a resale position from Rohm & Haas with ECA-5106R a lower cost, more shear stable replacement for Lz-3120. ECA-5106R was incorporated in the 5W-30 grade effective late 1970 but replaced almost immediately during the 1971 API-SE reformulation by ECA-5154, a PARAMINS resale of Acryloid 954 dispersant polymethacrylate viscosity improver.

A 5W-40 grade replaced the 5W-30 and the 0.9% ash level detergent inhibitor was 8.825 vol% ECA-5176 (ECA-1140 dispersant/M-400/ZDDP). ECA-5154 was also used as the viscosity improver for the 10W-40 grade. It was intended that the 5W40 grade should replace the 10W40 as well as the 5W30 but the 5W40 did not meet all the 10W40 requirements and the latter grade had to be retained.

One year later, the detergent inhibitor was optimized to 7.825% ECA-5125 using C-400 in 1972. Rohm & Haas improved the pour point performance of Acryloid 954 in MCT stocks and called it 954R. This was incorporated in mid-1974 and a 10W-50 grade added. Late in 1974, the 10W-40 grade was cancelled. The 10W50 was designed to compete with new 20W50 oils from other oil marketers.

By 1977 with the cost of petroleum products rapidly increasing, energy conservation became the prime focus of lubricant development.

Lubrizol offered a detergent inhibitor package Lz-4664 with a dispersant which was compatible with ECA 7812, the Exxon friction modifier. This was extensively field tested by the Research Department in a fleet of twenty purchased cars (40 drivers) and the 5W-30 grade showed a 2.7% fuel savings over the prior formulation (5W40).

Accordingly, based on this 600 k\$ field test, Fuel Economy UNIFLO 5W-30 was launched on the market early in 1978, accompanied by a 10W-40 grade with the same chemistry. The viscosity improver chosen was the new Lz-3702, wholly of Lubrizol manufacture. This project increased UNIFLO sales significantly and caught competition by surprise. Lz-4664 contained a sodium over based detergent and gave double IIIC performance. The new grades replaced the previous 5W40 and 10W50 formulations.

By 1980, reformulation was required to meet the API "SF" quality level and the Research Department had developed ECA-7084, compatible with ECA-7812. The combination designated ECA-7094 was based on conventional C-300 with the new ECA-5025 borated dispersant and 1.2% PARANOX 15 ZDDP. The antioxidant, ECA-7083 a sulphurized hindered phenol was also developed by the Research Department.

The viscosity improver was changed to Acryloid 953R to improve low temperature viscometrics, particularly at low shear rates. A 10W-30 grade was added in 1981.

When the 0.11% phosphorus maximum limit was defined in 1983 for the 1984 model year, the detergent inhibitor changed to 9.45 vol% ECA-9050, an M-400 formulation with some neutral calcium sulphonate to enhance diesel performance as API-CC was also a target for the 10W30 grade. The introduction of calcium also improved the water tolerance/filtration properties of UNIFLO - a finding translated from the ESSOLUBE XD-3 reformulation programme then active.

PROPRIETARY

A HISTORY OF IMPERIAL OIL'S
ENGINE OILS

D.H.T. Millard
September, 1986

Esso Petroleum Canada
Research Division
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Canada

This was later optimized in 1984 to 7.64% ECA-10200. Acryloid 953R viscosity improver was used at 7.1% in the 5W-30 grade. ECA-9072 dispersant OCP viscosity improver was used at 8.3% in the 10W-30 grade and at 5.2% in the 10W-40 grade along with 9.1% LZ 7322B styrene isoprene viscosity improver. All three grades gave excellent diesel performance meeting the API-CC level in the 5W-30 grade and API-CD in the other two grades. This is a current requirement to control deposit levels in turbocharged passenger car diesel and gasoline engines.

It should be noted that throughout its life, UNIFLO has almost always been formulated by the Research Department at Sarnia using the best available technology to make it a leading quality oil in the Canadian marketplace. L.W. Sproule, T.F. Lonstrup, W.C. Pattenden, D.E. Steere, G.E. Cranton, D.W. Murray, L.R. Carey and W.H. Stover have been the major contributors since the 1963 introduction. Targets and OEM intelligence were largely developed with Technical Services-Marketing (P.M. Krawchuk and G.W. Holmes).

Future developments call for upgrading the 5W30 grade to SF/CD to provide complete product differentiation from the ESSO EXTRA line (which is currently SF/CC). This would be a part-synthetic to meet both the low temperature viscometer and high temperature deposit control (CD) requirement. Also being considered are a full synthetic 0W30 and lower phosphorus (0.08% maximum) technology in anticipation of future OEM requirements for improved emission system efficiency.

The Uniflo product line was renamed Protec Ultra in mid-1986.

TABLE 5
UNIPLO

Year	Formula Insp.	DI vol%	VI vol%	Pour Pt or PD vol%	Viscosity			Ash wt% TBN	Ba/Ca	Mg	Zn/P	N/B	MIL-L	APT	Ind
					210°F/100°C SUS	100°F/100°C CST	0°F/-10°C Max.								
1965/12 10W-30	5.0 ENJ 546 2.3 ENJ 572 2.0 ENJ 1125 0.7 PAR 15	PN 440 6.0	-35F	67-70	12 K SUS	140	1.72/7	.83/	-	.097/.156	.04/	-	MS		
1965/04 SW-30	5.5 ENJ 1125 1.2 ECA 1708 0.8 PAR 15	Lz-3120 9.0	PF 322 0.8	67-69.5	4 K SUS	158	0.69/5	.7.14	-	.11/.10	.15/	-	SC	M2C-101A GM-4745M	
1966/08 SW-30	6.11 ECA-1721 1.8 ECA 1708 0.09 PAR 15	-	-	-	-	-	0.93/6	.7.23	-	-	.09/	-	-	-	
(switch to ECA-1030)															
1967/11 SW-30	9.6 ECA-1751 ECA-5120	8.5 8.425	PF 520 0.8	68-69.5	4 K/12 P	158/260	1.6/12	.04/.049	-	.11/.10	.05/	-	SD	M2C-101B GM-6041M	
1969/01 SW-30	10W-40	-	-	68-69.5	-	155/240	1.7/12	.7.44	-	.10/.09	.04/	-	SD	-	
1969/05 10W-40	-	Ac 726 10.3	-35F	80-82	/24 P	145/200	-	-	-	-	-	-	-	-	
1970/2 SW-30	-	ECA-5200 8.5	PF 520 -35F	83-84.9	/*	140/200	-	-	-	-	-	-	-	-	
Replaced by															M2C-101C GM-6140M
1971/02 5W-40	BCA-5175 8.825	BCA-5154 10.3	-40F	82-85	/12 P	150/220	0.9/6	-	0.185	.14/.125	.04/	-	SK		
10W-40	-	8.6	-	80-83	/24 P	142/188	-	-	-	-	-	-	-	-	
1972/01 5W-40	7.825	10.8	-	82-85	/12 P	150/220	1.0/5	.7.19	-	.16/.145	.03/	-	-	-	
10W-40	-	8.9	-	80-83	/24 P	144/190	-	-	-	-	-	-	-	-	
1974/07 5W-40	-	Ac 9548 9.7	PF 520 0.3	78-81	/12 P	210	-	-	-	-	-	-	-	-	
10W-40	-	9.5	-40F	80-83	/24 P	193	-	-	-	-	-	-	-	-	
10W-50	-	12.0	-	99-102	-	210	-	-	-	-	-	-	-	-	
1974/10 10W-40 Cancelled; 10W-50 Cancelled and 5W-40 Cancelled:															
1978/01 5W-30	7.9 Lz 4664 0.1 ECA 7812	Lz 3702 7.1	-40F	63-66	/12 P	190	1.0/	.7.145	Na.068	.142/.13	.04/	-	-	-	
1978/06 10W-40	-	8.0	-35F	78-81	/24 P	173	-	-	-	-	-	-	-	-	
1980/07 SW-30	7.6 ECA-7084 0.1 ECA-7812	Ac 9538 8.3	-42C	10.8-11.6	/12.5 P	205	-	.7.189	-	.164/.146	.065/.012	-	SP	M2C-153B GM-6048M	
1981/01 10W-40	7.7	9.7	-39C	14.7-15.4	/25 P	184	-	-	-	-	-	-	-	-	
1981/01 10W-30	-	6.1	-	10.8-11.6	-	162	-	-	-	-	-	-	-	-	

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TABLE 6 (Cont'd)

Year	Formula Insp.	DI vol%	VI vol%	Pour Pt or PD vol%	Viscosity			Ash wt% TBN	Ca	Mg	Zn/P	N/B	MIL-L	APT	Ind
					100°F CST	20°C Poises	Index								
1982/08 10W-30	ECA-9050 "	Ac 953R 5.3	-39C	10.9-11.5	25-33	161	-	.189	-	-	.164/.146	.065/.012	-	SP	
1983/06 SW-30	9.45	7.3	-42C	11.1-11.7	13.7-17.1	186	-	0.0195	0.118	.165/.103	.073/.0135	-	SP/CC		
Low temp. viscosity also measured by MRV effective 1982/08															
1984/06 SW-30	7.64	7.1	-42C	10.8-11.6	-25C 25-35	217	-	0.067	0.104	.163/.10	.07/.016	-	SP/CC		
ECA-10200	Ac 953R	8.3	-39C	9.6-10.4	25-35	135	-	-	-	-	-	-	-	SP/CD	
ECA-9072	9.1	Lz 7322B 5.2 ECA-9072	-	13.1-13.9	25-33	152	-	-	-	-	-	-	-	SP/CD	
1986/08 SW-30	-	Ac 953R 7.1	-42C	10.8-11.6	-25C 25-35	217	-	-	-	-	-	0.07/0.016	-	SP/CC	
ECA 9072B	8.6	-30C(1)	9.6-10.4	21-26	-	-	-	-	-	-	-	-	-	SP/CD	
"Protec Ultra"	10W-30	-	ECA 9072B Lz 7322B 8.9	13.1-13.9	26-31	-	-	-	-	-	-	-	-	SP/CD	

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(1) May require 0.1% Ac 154C.

PAR = PARANOV

ENJ = ENJUAR

LZ = LIQUOL

ECA = ESSO Chem Additive

AC = Acryloid (R&M)

PF = PARAFLOW

PN = PARATONE

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3.4 ESSO EXTRA MOTOR OIL (1959-) - see Table 7

This line of oils in 5W, 10W, 20 and 30 grades was developed by the Research Department in 1958 to supplement and eventually replace MARVELUBE which was proving borderline in varnish and rust performance for engines with hydraulic valve lifters. In 1956, GM Research noted that MARVELUBE was not up to the quality of the best competitive oils in rust and varnish in some 1955 Chevrolet V8 cyclic tests. The test procedure was a combination of FL2 low temperature conditions coupled with L-4 type high speed, high temperature conditions run alternately for 264 hours (including shutdowns). The Imperial Research Department found this GM procedure to be effective in discriminating between MARVELUBE and higher quality multigrade oils (Mobiloil Special 10W-30 and Texaco Havoline 10W-30). The test also correlated well with 1955 fleet test results. Accordingly, it was used to select the detergent inhibitor for ESSO EXTRA MOTOR OIL.

A comparison between Lz 6266, Lz 7881A and PARANOX 301 (+0.7 vol% ZDDP Lz 1360) at equivalent treating cost for Supplement I in 30 grade oils showed the latter to be clearly superior. Chevrolet V8 engine rust tests indicated the addition of 1.5 vol% PARANOX 30 (barium sulphonate) would provide excellent rust protection for hydraulic valve lifters. The total package of PARANOX 301 (73%) plus PARANOX 30 (27%) was designated ENJ-425 and was used at 7.5 vol% + 1 vol% Lz 1360 in the 5W, dropping to 5.6 vol% + 0.7 vol% Lz 1360 in the 30 grade. This formulation was successfully marketed until 1965. In 1965, its sludge performance (without ashless dispersant) and cost dictated the need for new technology to meet the MS-64 (API-SC) specifications Ford M2C-101A and GM-4745M for 'Sequence Tested' oils.

In 1964-65 Imperial Oil's Chemical Product Department had built additive manufacturing and blending facilities at Sarnia to make PARANOX 351 (barium phosphonate) and ECA-1030 (PIBSA-TEPA) ashless dispersant. The ESSO EXTRA MOTOR OIL reformulation was based on 3.5 vol% ECA-1030 + 1 vol% ENJ-1038 (C-300) + 0.7-1.0 vol% PARANOX 15 (ZDDP).

This lasted until the next industry quality change to API-SD in 1968 to meet Ford M2C-101B and GM-6042M specifications for 'Warranty Approved' oils.

At this time, multigrade oils were taking a significant share of the market and it was decided to eliminate the 10W, 20 and 30 grades in favour of two multigrades 5W-20 and 10W-30 while retaining the 5W for export to Scandinavia. The SD quality level demanded outstanding rust protection to cope with the Ford Falcon rust test. This engine responded mainly to high alkalinity (about 9 TBN minimum). The detergent inhibitor chosen was 6.5 vol% ECA-5121 (1.8% ECA-1030 + 1.3% ECA-1140 + 2.5% ECA-5126 (C-400) + 0.7% PAR 15 + 0.2% PLEXOL 305 (RI)). There was some indication of synergism between ECA-1030 and Lz-936 (PIBSA-PAM dispersant) in this engine test program but ECA-1140 (PIBSA-PAM) gave equivalent results in the MS Sequence VB test so was chosen as a future 'in-house' dispersant to be made at Sarnia.

The viscosity improver chosen was the new acrylate type resold from Union Carbide via Lubrizol, i.e. Lz 3120. This was replaced in late 1970 by ECA-5106R a lower cost methacrylate (non-dispersant) type resold from Rohm and Haas by Esso Chemical Canada's PARAMINS Division.

The next reformulation to API-SE quality level occurred in mid-1971 to meet the Ford M2C-101C, GM-6136M specifications. The detergent inhibitor was ECA-5174 at 9.5 vol% based on ECA-1140 dispersant, PARANOX 351 and ECA-4568 (C-300). The emphasis was on antioxidant capability in the Oldsmobile IIIC test so that ECA-4493 (sulphurized terpene) was used at 0.75 vol% to supplement 0.9 vol% PARANOX 15. The viscosity improver was the new PARAMINS OCP type ECA-4542 later made at Sarnia as ECA-5127 and eventually branded PARATONE 717. In 1972, the 5W-20 was changed to the UNIFLO detergent inhibitor/viscosity improver (ECA-5125/ECA-5154) to provide better low temperature properties. This brand was cancelled in early 1974 following the November 1973 introduction of ESSO EXTRA MOTOR OIL 5W-30 based on ECA-5174 and Acryloid 954R. The 10W-30 was changed from ECA-4542 imported OCP to Sarnia made PARATONE 717 in early 1972.

The next reformulation introduced new lower cost API-SE/CC technology from PARAMINS in 1976. The detergent inhibitor was ECA-7032 containing the new borated ECA-5025 PIBSA-PAM dispersant and Bryton M-400 (magnesium sulphonate) and 7.6 vol% ECA-7032 replaced 9.75 vol% ECA-5174 while providing better diesel performance. The viscosity improver was Acryloid 954R in the 5W-30 and a combination of ECA-5127/Ac 954R in the 10W-30. Three years later, in early 1979, the next reformulation to the API-SF level, for 1980 model cars, occurred. The emphasis was on valve train wear in the MS Sequence 5D (4 cyl 2.3 L Pinto engine) plus additional oxidation stability in the MS Sequence IID Oldsmobile test. The detergent inhibitor was 8.9 vol% ECA-7046 in all grades with Acryloid 953R (more shear stable than 954R) in the 5W-30. This grade was cancelled at the end of 1979 as it competed with UNIFLO 5W-30 which had been reformulated to use the new EXXON fuel economy additive ECA-7812.

The 10W-30 used a combination of PARATONE 717 and Acryloid 953R viscosity improvers while the new 10W-40 grade used 14.8 vol% PARATONE 717. This grade was cancelled in mid 1982 but the formulation remained as ESSOLUBE HDX PLUS 10W-40.

The remaining 10W-30 was reformulated to PARAMINS new copper antioxidant and fuel economy technology ECA-9041A detergent inhibitor with the same viscosity improver system (PARATONE 717/Ac 953R) in August 1982.

In 1984, a 20W50 grade (previously marketed as ESSOLUBE HDX PLUS 20-50) was introduced in response to customer requests for imported European cars and for motorcycles which specified this multigrade. In 1985, a 5W30 grade was re-introduced using a Lubrizol detergent inhibitor (Lz 7592A) and styrene-isoprene copolymer viscosity modifier (Lz 7322B) in response to OEM recognition of the low temperature performance and fuel economy benefits associated with this grade. For the 1986 model year about 60% of new cars specify 5W30 as the prime viscosity grade recommendations.

Since 1976 ESSO EXTRA MOTOR OIL and ESSOLUBE HDX PLUS have used essentially the same formulation to meet similar targets. Additional comments on recent technology for these product lines are included in the ESSOLUBE HDX PLUS section.

In 1984, "ESSO EXTRA MOTOR OIL" was renamed "ESSO EXTRA ENGINE OIL" and in 1986, the 10W30 and 20W50 grades were reformulated to the shear stable, dispersant viscosity modifier ECA 8899 with a dispersant reduced version of the previous copper containing detergent inhibitor (ECA 9076D). Manufacture of the dispersant (multifunctional) OCP viscosity modifier, also used in Essolube XD-3 commenced in Sarnia in January 1986. In 1986, the product line was renamed Protec Extra.

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3.5 ESSOLUBE HDX 1959-73 (HDX PLUS 1973) (Table 8)

Introduced in the late 1950's as a higher quality brand than ESSOLUBE HD which was at the MIL-L-2104A level, ESSOLUBE HDX met the MIL-L-2104A Amendment I or Supplement I specification which required 1% Sulphur content fuel in the Caterpillar 1-A 480 hour engine test.

Technical Services-Marketing reviewed the field performance of the ENJ-569 formulation and, by 1961, reached the conclusion that (a) it was weak and (b) oil costs were too high due to the 5.8 vol% additive treat. Refinery Sales had a low cost Supplement I oil based on a 3.3 vol% treatment (2.8 PARANOX 351/0.5 PARANOX 15) and the Caterpillar data indicated lower deposit levels than for the 5.8 (ENJ-569 + ZDDP) treatment. Since Research felt the 3.3% level was borderline and based on a fortuitous engine test, it was agreed to uptreat to 3.4 vol% PARANOX 351 + 0.7 vol% PARANOX 15. This formulation was established in 1962 and was fully MS Sequence Tested as well as Supplement I approved. It was upgraded by the addition of ashless dispersant and C-300 in 1965 to meet MIL-L-2104B, Ford M2C-101A and GM4745M at the SC/CC quality level. A 10W-30 version at the SC/CB level was introduced the same year but quickly upgraded to MIL-L-2104B SC/CC to meet competitive levels.

The same formulation DI 5.75 vol% ECA-1725 was used in a 5W-20 version introduced in October 1965 and both multigrades used the newly introduced Lubrizol VI Lz-3120 based on acrylate resin from Union Carbide.

By 1966, PARAMINS had optimized the straight grade treatment to 4.15 vol% ECA-1728. Field performance in most diesel engines was satisfactory but reduced fire ring sticking in Detroit Diesel 2-cycle 6-71 engines was desired. Ash levels were below 1% max. during this period.

In 1968, Ford M2C-101B specification for 'Warranty Approved' MS-68 oils at the SD/CC API level required an additional engine test - the Ford Falcon rust test. This engine had severe field rust problems due to its Positive Crankcase Ventilation (PCV) emission system. To pass the engine test, the oil was found to need high alkalinity of 9 TBN minimum which was obtained by adding overbased calcium sulphonate either C-300 or C-400.

The oil's sulphated ash level rose to 1.5% or more and Caterpillar 1H2 performance was unchanged or improved since Caterpillars were designed to operate on high ash Series 3 oils. However, two field problems occurred with all the MS-68 oils. Firstly, Detroit Diesel fire ring sticking occurred much earlier than before due to the high ash deposits from the oil in the ring zone. This caused top compression ring sticking and loss of oil consumption control and compression. Secondly, Cummins Diesel had recently introduced exhaust turbocharged engines with an oil seal problem (NTC 335 models) caused by mechanical distortion which resulted in high oil consumption. To some extent, earlier lower quality oils were believed to allow varnish to build up on the seal and aid in reducing oil consumption - this was the Cummins field personnel initial position. The MS-68 oils were alleged to 'clean-up' the seals and increase oil consumption so Cummins recommended against them.

At this time, Cummins had 41% of new truck engine sales and GMC (Detroit Diesel Engines mostly) had 38% - so the impact of the field problems on Imperial was considerable.

ESSOLUBE HD was reintroduced with the 1966 ESSOLUBE HDX formulation. RPM Delo HD was an immediate field recommendation as a low ash oil and ESSOLUBE HDX was reformulated from 7.3 vol% ECA-1752 to 6.8 vol% ECA-5122B which was essentially double treat of the 1966 ESSOLUBE HDX formulation components. The same approach was taken with the multigrades. Meanwhile, Cummins redesigned their turbocharger and the new 1969 ESSOLUBE HDX gave satisfactory performance in the modified engines. Detroit Diesel issued service bulletins limiting oil ash levels to 1% max. so ESSOLUBE HDX was no longer recommended for Diesel Diesel 2-cycle engines but was satisfactory for the small population of 4-cycle Detroit Diesel engines just starting to appear.

Some 1971 model cars required warranty approved SE oils and the corresponding MIL spec was MIL-L-46152. Caterpillar 1H2 severity at the independent test sites increased during this period to the point where 10W and 10W-30 oils were virtually impossible to pass. Ford had dropped the Falcon test from M2C-96B and M2C-101C specifications and agreed that the MSIC Oldsmobile test would satisfy their rust performance needs. This allowed oil ash levels to drop back to the 1% level desired to meet Detroit Diesel 2-cycle requirements. Lubrizol obtained 10W and 10W-30 Caterpillar 1H2 passes in their own engine laboratory at Cleveland, Ohio, which PARAMINS was unable to match.

Accordingly, Lz-4480 was used in ESSOLUBE HDX 10W, 5W-20 and 10W-30 until 1976. This was a C-400, dispersant and ZDDP formulation. The dispersant was unique in that pentaerythritol was used instead of polyamine as the surfactant tail on the PIBSA and it was therefore a non-nitrogen dispersant. PARAMINS retained the 20 and other heavier grades as well as the 5W-30 grade introduced in 1969, with PARANOX 351/C-300/dispersant/ZDDP formulations. In 1975, a 15W-40 grade was introduced using 9.75 vol% ECA-5174 detergent inhibitor and 13.2% PARATONE 717 viscosity improver. Previously, Lz-3120 viscosity improver had been found to have insufficient shear stability for 'stay in grade' passenger car performance and had been replaced by ECA-5106R (resale from Rohm & Haas), in 1970. By 1971, ECA-5154 (resale Acryloid 954) was used for the 5W multigrades as a more shear stable dispersant viscosity improver with good low temperature properties. PARATONE 717, ethylene-propylene copolymer otherwise known as olefin copolymer (OCP) was used for the 10W-30 and heavier multigrades, as it was now manufactured at Sarnia from Exxon synthetic rubber, but had only fair low temperature properties. A 20W-50 grade was established in 1972.

In 1976, PARAMINS regained the total detergent inhibitor business with a low ash formula 7.6% ECA-7032 (0.7 wt% ash - all M-400 with ECA-5025 dispersant) and henceforward, ESSOLUBE HDX and ESSO EXTRA MOTOR OIL were essentially on the same formulation as targets were similar. The 15W-40 grade was cancelled in 1978.

ECA-7032 was replaced by 8.9 vol% ECA-7046, a similar 0.7 ash formulation with higher ZDDP level meeting MIL-L-46152B at the SF/CC quality level in 1980. The selection of M-400 (ECA-5087) narrowed down to the Witco alcoholate (or metal) process from their Trainor, Pa. plant. The M-400 made by the lower cost and more commonly used magnesium oxide process used by Surpass Chemicals and Witco's other plants was found to be susceptible to bearing corrosion induced by glycol antifreeze contamination. L-38 single cylinder engine bearing corrosion test with glycol added to the oil showed severe corrosion in the 400 mg range or 10 times normal. This confirmed field reports of high bearing weight loss with the oxide type M-400.

The next reformulation in 1981-82 to ECA-9027B was driven by the 0.11% phosphorus limitation (emission catalyst protection) and fuel economy requirement for ESSO EXTRA MOTOR OIL.

However, ECA-9027B was not commercialized for long due to incompatibility between the phenate and sulphonate which caused haze and sediment in the oil.

Lubrizol 7560 was used for a few months until ECA-9041A based on PARAMINS new copper chemistry which gave excellent IID antioxidant performance at lower ZDDP levels was approved against MIL-L-46152B (SF/CC) and the industry Energy Conserving requirements.

The reformulation occurred in 1982/83 and is still in use to date for the single grades, however, together with Esso Extra Engine oils, the multigrades were reformulated in 1986/87 to ECA 8899, the shear stable multifunctional OCP viscosity improver and a dispersant reduced version of the copper containing detergent inhibitor, ECA 9076B. Glycol induced bearing corrosion remains a concern and potential supply problems with ECA 5087 (alcoholate M400 detergent) may accelerate the next reformulation.

While the detergent inhibitor remained constant during 1983-85, industry concern about low temperature field problems caused several revisions to the pour depressant used in PARATONE 717. The 1980 introduction of the SAE low shear Mini Rotary Viscometer was designed to provide winter grade oil specifications which would eliminate low temperature pumping and oil distribution problems within the engine. However, from 1980-82, camshaft failures were traced to slow cooling rates causing oil gelation and consequent pumping failures. Sarnia Research modified the MRV cooling rate and the industry adopted it. Although ESSO branded products were not implicated in the field problems it was found that some batches of ESSOLUBE HDX PLUS (ESSO EXTRA MOTOR OIL) 10W-30 and ESSOLUBE XD-3 multigrade using PARATONE 717 (ECA-5127) gave gelation on slow cooling. This was found to be pour depressant related and a change to ECA-9399 PD was made. Later this was changed to ECA-9153 which optimized both pour response and slow cool MRV performance. The pour depressed viscosity improver corresponding to these changes was ECA 5127A and later ECA 5127B. Similar modifications were made to the pour depressant used in ECA 8899, the multifunctional OCP viscosity modifier now used in ESSOLUBE HDX PLUS, ESSO EXTRA ENGINE OIL (Protec Extra) and ESSOLUBE XD-3.

TABLE 8. (Cont'd.)

Year	Formula	DI	VI	Pour Pt or Po wt%	Viscosity 210°F/100°C wt%	Viscosity 60°F/18°C wt%	Revolube XD-3		Wt% Ba/Ca	Wt% Ba/Ca	Wt% Ba/Ca	Wt% Ba/Ca	MIL-L- APL	Ind
							Min	Max						
1976/04 15W-40 7.6	REK-7032	REK-5127	12.0	-35°F	75-78	48 P	148	175	-	0.065	-17.15	.09/.015	46152	SE/CC
1978/04 Brand Cancelled	AC-9548	-39°C	-	-	-	-	-	-	-	-	-	-	QL	QL
1976/04 (43) 10W-30 7.6	REK-7032	8.2 REK-5127	1.0 AC-9548	-	63-66	724 P	142	175	-	0.065	-17.15	.09/.015	46152	SE/CC
1976/04 20W-50 7.6	REK-7032	REK-5127	11.5	-35°F	87-90	710 P	138	175	-	-	-	-	-	-
1977/05(1) 30	-	AC-9548	-39°C	-	-	-	-	-	-	-	-	-	-	-
1979/06(1) 10W 8.3	REK-7046	REK-5127	0.21	65-68	-	93	-	-	-	-	-	-	-	46152 SE/CC MC-37C
1979/06(2) 10W 8.3	(4) REK-9041A	REK-5127	0.5	45-47	725 P	98	-	-	0.099	.16/.14	.07/.011	46152B SE/CC	-	
1982/08(2) 10W 7.9	-	REK-5127	0.4	5.8-6.4	33 P @ -20°C	104	0.97	CU 0.0115	0.12	.12/.105	.07/.015	-	-	-
1979/06 5W-20 8.9	REK-7046	REK-5127	5.6	54.5-57.5	712.5	185	0.75	-	0.099	.16/.14	.07/.011	QL	QL	
2006/50	-	REK-5127	12.2	87-90	775	131	-	-	-	-	-	-	-	-
10W-30	-	REK-5127	10.0	63-66	725	138	-	-	-	-	-	-	-	46152B SE/CC MC-94B
1982/08 5W-20 7.9	REK-9041A	REK-5127	5.1	42°C	8.4-9.2	16.1 P @ -20°C	186	0.97	CU 0.0115	0.12	.12/.105	.07/.015	QL	QL
(Viscosity CCS Pulse @ -25°C = 20-30; MVN Pulse @ -20°C = 300 max.; Yield Stress MVN Pascals @ -30°C = 105 max.)														
2006/50 7.9	REK-9041A	6.3 REK-5127 MC-199C	1.0 AC-9548	0.1	16.8-17.6	122	0.97	CU 0.0115	0.12	.12/.105	.07/.015	QL	QL	
(Viscosity CCS Pulse @ -10°C = 28-43; MVN Pulse @ -15°C = 300 max.; Yield Stress MVN Pascals @ -15°C = 105 max.)														
10W-30	REK-9041A	6.5 REK-5127	1.0 AC-9548	0.1	10.8-11.6	147	0.97	CU 0.0115	0.12	.12/.105	.07/.015	46152B SE/CC MC-94B	-	
(Viscosity CCS Pulse @ -25°C = 25-33; MVN Pulse @ -25°C = 300 max.; Yield Stress MVN Pascals @ -25°C = 105 max.)														
(1) ALSO ESSO PLUS MOTOR OIL for service stations. (2) Other straight grades used same formulation. (3) Became rebrand of ESSO EXTRA MOTOR OIL 10W-30. (4) Prior to REK-9041A, a LE MDO DI was used for several months in 1982 as REK-90278 was rejected due to a haze and sediment problem.														
PAR = PARAFFIN REK = ESSO CHEM Additive L2 = Lubritrol (SAH) AC = Acryloid (SAH) PP = Parafinow QL = Quality Level														
REK-903														
0674a														

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3.6 ESSOLUBE D-3/XD-3 1956- (Table 9)

Essolube D-3 replaced Imperial SDX Caterpillar Series 2 oil in the mid 1950's when the Caterpillar Series 3 quality level was introduced.

The 15.5 vol% PARANOX 205 formulation chosen gave excellent field and engine test performance in a variety of turbocharged diesel engines where this quality level was specified by the OEM. It was a combination of barium sulphonate (PARANOX 30) and barium-calcium phenate (PARANOX 43) giving a high sulphated ash level (3.7 wt%). However, the clean deposition characteristics of barium in combustion chambers and ring zone caused no excessive ash problems.

In 1960, the formulation was changed to 14.4 vol% ENJ-425 for logistics and cost reasons. This was the additive used in ESSO Extra Motor Oil.

However, field performance was not as good in terms of ring zone cleanliness and ring sticking, so in 1962 D-3 reverted to PARANOX 205 once more.

MIL-L-45199 and 3-GP-346a approvals were now obtained.

In 1964, D-3 was reformulated to 14.3 vol% ECA-190 to reduce cost and incorporate a minimum ZDDP content (0.05 wt% Zn) so that the oil could be used in mixed fleet operation (also including gasoline engines) without catastrophic valve train wear. ECA-190 contained 300 TBN calcium overbased sulphonate ENJ-1038 as the main detergent along with PARANOX 30.

ENJ-1038 was made by Bryton (later Witco) Chemical and was generally designated as C-300. Surpass Chemicals, Scarborough, Ontario later made acceptable lower cost C-300 versions.

14.3 vol% ECA-190 in MCT stocks was approved against MIL-L-45199A.

By 1966, demand was growing for mixed fleet oils that would truly meet SC gasoline engine performance. Accordingly, D-3 was reformulated to 11 vol% ECA-1731 (0.07 wt% Zn) CD/SC quality, suitable for the then current gasoline engines.

With the advent of MIL-L-2104C and MIL-L-46152 specifications in 1970, another reformulation was made to 10.5% ECA-5171 which provided both these approvals and CD/SE performance. However, truly Universal Oil performance was not provided until 1972 when the ash level was reduced to 1 wt% max. thus meeting the Detroit Diesel (2 cycle) oil targets. This new formulation, ESSOLUBE XD-3, was extensively field tested in Detroit Diesel and Cummins engines and found to give outstanding results despite a relatively low fresh oil TBN. The dosage of 13.75 vol% ECA-7003 contained C-300, barium sulphonate, barium/calcium phenate, mixed alkyl and aryl ZDDP plus 7.5 vol% ECA-1140 polyisobutylene succinamide dispersant. It met MIL-L-2104C and MIL-L-46152.

A 10W-30 grade using the same detergent inhibitor and with ECA-5127* OCP Viscosity Improver was introduced in 1972 along with 5W-20 and Lotemp 5W-20 grades. The 5W-20 grades used Acryloid 954R methacrylate Viscosity Improver and a 1% dispersant credit reduced the DI treat to 12.75 vol% ECA-7006. The Lotemp 5W-20 was part-synthetic, containing 20 vol% Emery 2958, 0.5% ECA-4818 (Vistone 3 oiliness agent) and 0.3% additional ZDDP (PARANOX 15). This became a popular oil in the far north because of its outstanding low temperature performance and 'universal oil' characteristics. In 1975, a 15W-40 grade was introduced with ECA-5127* OCP VI and was destined to become the most popular future grade.

(* ECA-5127 = PARATONE 717)

By 1977, with a need for higher TBN for longer oil drains and "CD" performance on the 15W-40 grade, a reformulation to 11.3 vol% ECA-7075 occurred. This was a relatively low cost 1% ash formulation incorporating four new components M-300 (magnesium overbased sulphonate) and ECA-5025 a borated succinamide dispersant. The barium components were eliminated and calcium phenate introduced (ECA-6311) along with magnesium phenate (ECA-4999). However, ECA-6311 and to a lesser extent, ECA-4999, used ethylene glycol as a process solvent in their manufacture which caused a positive glycol reaction in fresh XD-3 of up to 400 ppm by the ASTM D2982 test. This and other glycol detection tests used by fleet customers to monitor gasket sealing on rebuilt engines caused an adverse field reaction to the new formulation resulting in loss of the Sherritt Gordon mines account. The problem was minimized but not completely solved by expensive glycol stripping of ECA-6311.

Both 5W-20 grades contained 1.9 vol% additional aryl ZDDP to provide both increased high temperature stability and additional antiwear performance in view of their low viscosity. Both used Uniflo base oil and in 1978 Lotemp 5W-20 was renamed Essolube XD-3 Arctic 5W-20 and reformulated to 13.29 vol% ECA-7064.

In 1977, the 15W-40 was reformulated to 15% ECA-7055A/11.8% ECA 5127 fully meeting MIL-L-46152/2104C and Mack EO-H requirements. ECA-7055A was essentially similar to ECA-7075 described above.

1980 saw the advent of SF, Fuel Economy and the MIL-L-46152B (SF-CC) specification which required yet another reformulation to 12 vol% ECA-7099 detergent inhibitor for the straight grades and 13.5 vol% in the 15W-40 (+12.7 PARATONE 717).

This was a low glycol content magnesium/zinc/dispersant formulation from PARAMINS and caused initial concerns with LA-161 compatibility (fuel economy friction reducer) which was solved by overnight stirring of the oil blend (at least eight hours). Another problem was water sensitivity plus related oil filter clogging, publicized by Cummins Diesel, to which all magnesium formulations seemed more susceptible than calcium formulations.

Thus, the scene was set for a shift to calcium phenate technology or at least calcium/magnesium blends. By this time, fuel economy from low friction engine oils had become of lower concern to the OEM and fleet operators than engine durability. Accordingly, it was decided to delete LA-161 because of its cost and additive compatibility problems. This decision was reinforced by increasing evidence that, in heavy duty service, viscometrics rather than friction modifiers play the largest role in achieving fuel savings.

In 1981, the Arctic 5W-20 was replaced by an ARCTIC 0W-30 formulation using 13.5 vol% ECA-7099 with 7.7 vol% Acryloid 953R. The basestock was 24.6% Gulf 4 cSt Polyalphaolefin (PAO), 7% ECA-7267 ester and 49.8% Uniflo Base. The mixed synthetics provided desirable oil seal swell and low temperature characteristics.

Mack Truck introduced the EO-K oil quality level in 1979 aimed at reducing piston crown land deposits which had been causing bore polishing and high oil consumption in their new low emission engines where clearance between crown land and cylinder bore had been substantially reduced. A new Mack factory fill brand, Mack EO-K oil, was introduced as a 15W-40 formulation in 1980 based first on 15 vol% ECA-7437A and 5 months later on the new 1% ash 16.5% PARANOX 276 treatment.

Although PARANOX 276 had been extensively tested in Mack T-6 engine tests at various laboratories, it did not perform as well in some Research Department turbocharged Petter tests as Lubrizol and Oronite calcium formulations. These results were later confirmed in Mack & Cummins field tests which showed the Oronite technology to be superior to both PARAMINS and Lubrizol detergent inhibitors.

These data together with the glycol content of PX 276 caused a preference for the OLOA-8716A formulation. Thus, in 1982, Essolube EO-K was introduced with 16.6 vol% OLOA-8716A, 6.4 vol% Acryloid 953R and replaced Mack EO-K 15W-40. ESSOLUBE EO-K was later renamed Essolube HD 15W-40 (a CD EO-K/2 diesel oil). The Mack EO-K/2 specification was introduced in 1984, adding the Mack T-7 test to the T-6 test (which defined EO-K performance), due to concerns with oil thickening with high BMEP, low rpm engines in stop and go service.

In 1984, ESSOLUBE XD-3 15W-40 was reformulated to OLOA-8162C at 11 vol% with 10.2 vol% ECA-9072 (ECA 8899 + pour depressant) dispersant OCP viscosity improver. The MIL-L-2104D specification was established in 1983 and caused this latest reformulation along with the calcium preference and the need in the market for Universal Oil/EO-K performance (EO-K/2 in late 1984). The ECA 9072 viscosity improver was found to give a minimum Caterpillar 1G2 debit in multigrade formulations. Initially imported from PARAMINS in the US, ECA-9072 manufacture was established by PARAMINS at Sarnia in 1986.

The monogrades remained with PARAMINS using 11.8 vol% ECA-9063 (mixed calcium/magnesium DI) to meet MIL-L-2104D/46152B and Cummins water tolerance requirements.

The 1984 reformulations raised the ash level to 1.4 wt% however these oils were suitable for Detroit Diesel engines (2 cycle) as this OEM had relaxed its 1% max. ash level in favour of proven field performance.

In 1985, PARAMINS qualified ECA 9063 in multigrade formulations and, since field testing had confirmed its acceptability as a replacement for OLOA-8162C, a formulation change was made in 1986.

An increasing trend in recent years has been the adoption of multigrade oils by the OEM for heavy duty service. Imperial has been at the forefront of this development which was encouraged by the oil consumption and fuel economy benefits as well as the 'All Season' convenience and inventory simplification of one oil grade. While 15W40 has been the dominant grade there are indications that 10W-30 could be increasingly popular in Canada. The advent of higher operating temperature (for fuel economy) and tight crown land pistons (for emission control) are increasing oil performance problems. Crown land deposits which, when excessive, can lead to bore polishing and oil consumption problems in recent Mack & Cummins NTC 400 engines. Other European OEM's have experienced similar problems. The next few years will be critical for additive and oil companies in the development of new HD oil technology to alleviate this problem.

Currently, the industry is debating the next quality level for heavy duty engine oils, recognizing that the definition of CD performance by the single cylinder Caterpillar 1G/2 test is outdated and of little relevance to current engines. CB has been proposed as CD plus passing results in the multicylinder Cummins NTC 400, Mack T-6 and T-7 tests, however, this definition has not as yet been universally endorsed. In addition, other proposals (e.g. PC-3 and PC-1) are being debated to meet both current and future engine requirements. While the final results of this debate are unclear, it is clear that future qualification of heavy duty engine oils will be a difficult and expensive process. Meanwhile, Imperial's strategy is to position ESSOLUBE XD-3 as the large volume oil meeting current industry specifications and ESSOLUBE HD as the 'pacesetter' oil meeting anticipated future specifications and using the best available additive technology.

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TABLE 10

RAILWAY DIESEL LOCOMOTIVES IN CANADA - 1952

Railway	Now in Service		Estimated by 1955	
	Main Line	Switchers	Main Line	Switchers
CPR	115	144	270	225
CNR	96	155	300+	300+
ACR	24	5(1)	24	5
C&O	19	5(1)	19	5
ON	17	5	24	7
P&G	6	2(1)	6	2
TH&B	16	2(1)	16	2
Wabash	24	5(1)	24	5
Others	12	16	14	20
	329	339	697	571

(1) No additional units expected.

TABLE 11

STEAM LOCOMOTIVES OPERATED BY THE CPR AND CNR - 1951

Railway	Main Line	Switchers	Total	No. of Diesels to
				Replace Steam(2)
CPR	1440	243	1683	1353
CNR	1849	429	2278	1823
			3961	3176

(2) 80% Diesels replace 100% Steam.

This indicates the rapidly growing market for railroad diesel fuel and engine oils during the 1950-60 period. Engines were in the 1000-1500 HP range and oil drain intervals at 120,000 miles. By 1955, new locomotives were 1750 HP (EMD 567C at 850 RPM).

4.2 GALENA RD-76 (1952-1966)

Prior to 1950, experience in 2-cycle diesel and natural gas engine lubrication had defined a suitable base oil LCT 40X. This was a mildly phenol extracted Tia Juana 102 distillate. However, Imperial's first railroad diesel oil QXS-109A was based on Standard Oil Development Company's WS-1247 in order to obtain an approval to field test in September 1950. QXS-109A used LCT-25 and MCL-60 base oils with 4.4% PARANOX 47, 0.1% PARAFLOW C-12 to 0.01% DC-200 antifoam.

This unsuccessful formulation was withdrawn from field test by May 1951 due to excessive viscosity increase. In the meantime, a new detergent inhibitor, PARANOX 65 was recommended by SOD Research Division as it was being used in DIOL RD-76 field tests in the U.S. Accordingly, QXS-109C with 2.8% PARANOX 65 in LCT-40X based was submitted to ALCO in mid-1950 for bench engine testing. This was successful at 750 hours and the oil was also approved by EMD on the basis of silver bearing and oxidation tests. However, the rate of additive depletion in the engine test suggested a higher level be used in the field and QXS-109D containing 3.5% PARANOX 65 was finally submitted for field test in February 1951.

In April 1951, the CPR and CNR advised they were increasing oil drain intervals from 60,000 to 120,000 miles - the first mechanical inspection point. Accordingly, the PARANOX 65 content was increased to 4.5 vol% in the field test oil (QXS-109E) which was supplied to the railways as a no cost replacement for QXS-109A. At this time, ALCO (MLW) engines were experiencing main bearing failures on Texaco Dieseltex HD-40 oil. Technical Services-Marketing felt that competitive advantage could be gained if Galena RD-76 had reduced bearing corrosion tendencies in the 36 hour Chevrolet L-4 test (Copper-Lead Bearings). The addition of 0.3 vol% Santolube 394C lowered corrosion to 35 mg/bearing well under the competitive oil. This formulation QS-109F was approved by EMD and branded Galena RD-76 in May 1952. It was destined to become the railroad diesel engine oil standard for Canada for the next five years.

Late in 1952, Dieseltex 1669, the main competitive oil, was rejected by both CNR and CPR due to short oil life, dirty engines and piston cracking.

Galena RD-76 gained more than 85% of the railroad crankcase oil market and its performance allowed the CPR to extend engine overhaul from 240 k miles to 360 k miles by 1956 with oil drains at 120 k miles.

CNR went further by eliminating oil drains until main engine repairs were required which averaged 300 k miles in heavy freight service and 500-600 k miles in passenger train service.

The EMD 567C locomotives were developing 1750 HP from the same size engine used in the 1500 HP 567B units. Thus, Galena RD-76 was asked to provide extended oil drains in higher severity engines.

It was not surprising that field problems began to occur.

4.2.1 Field Problems 1957-64

Mid-1957

CPR reported the used oil showed considerable increase in pentane insolubles and sulphated ash. 7% of 567C units showing some lead overlay removal from main bearings at 120 k miles.

Early 1958

TS-Marketing reported excessive engine deposits in some units at Calgary with the used oil showing a distinct reddish colour, loss of dispersancy by blotter spot test, a high total acid number and a low total base number.

CNR began to report piston pin lubrication failures with silver bearings in 567C units in both freight and passenger service. However, samples of 1954 and 1958 production Galena RD-76 submitted to EMD for 100 hour silver lubricity tests showed satisfactory performance. The problem was traced to plugging of the oil groove in the piston pin with sludge deposits likely caused by the extended (or no) oil drain policy of the Canadian railways. The CNR tested some modified piston pins with improved oil groove/flow design and this alleviated this problem.

Early 1960

CNR advised Imperial that Galena RD-76 appeared to have changed in quality, giving shorter oil life plus an alarming increase in main bearing and crankshaft failures. CPR later confirmed these observations.

The following table illustrate the severity of the problem:

TABLE 12 RAILROAD FIELD PROBLEMS 1957-64

	% OIL CHANGES DUE TO HIGH VISCOSITY/OXIDATION						
	1955	1956	1957	1958	1959	1960	1961
CPR (Alyth Shop)	0	1	4	16	34	21	12
CNR (Mimico Shop)	-	-	-	6	18	7	-
(% oil inspections 84+ SUS at 210°F)							
CPR AVERAGE MILES BEFORE OIL CHANGE							
K Miles	1957	1958	1959	01-06		07-10	
	567B Engines	83	49	39		47	
	567C Engines	72	63	58		54	
				33		33	
% INCIDENCE OF CRANKSHAFT FAILURE							
	1948-57	1958	1959	1960		01-06	
	CNR (All Shops)	0.3	0.6	0.7		1.0	
% OIL CHANGES CAUSED BY WATER OR CHROMATE DETECTION							
	1955	1956	1957	1958	1959	1960	1961
	CPR (Alyth)	5	6	3	8	14	21
	CNR (Mimico)(1)	-	-	-	-	2	6
	(1) % oil tests showing a 2 or higher rating in CRN chromate test (50+ ppm chromate)					13	

The above data lead to three possible inferences:

1. The quality of Galena RD-76 deteriorated starting about 1958.
2. The CNR was the main complainant on crankshaft failures.
3. Coolant leakage into the crankcase oil increased from 1958 onwards and possibly reflected a lowering of maintenance standards by the two major railways.

4.2.2 Changes in the Composition of GALENA RD-76

(a) Base stock was changed from clay treating to hydrofinishing in early 1959. This was reversed in mid-1960 in an effort to alleviate the field problems.

(b) PARANOX 65 was composed of 71.4% Barium Nonyl Phenol Sulphide (PARANOX 47) plus 28.6% Calcium Sulphonate (neutral 45% soap) (PARANOX 24).

PARANOX 47 Manufacturing Changes

Mid-1956	change from batch process to continuous process Nonyl phenol Sulphide (NPS)
Mid-1957	change from sequential to simultaneous CO ₂ treatment (overbasing)

PARANOX 24 Source Changes

1956 - 1959-06	Ultra Penn or Baytown Synthetic Sulphonate
1959-06 - 1960-06	Sonneborn Petroleum Sulphonate
1960-06 -	Bryton (later Surpass) Synthetic Sulphonate

These changes apparently had no effect on laboratory oil stability tests as evidenced by EBB lube stability testing at 340°F.

4.2.3 Simulation of Field Bearing Failures

A laboratory main bearing rig based on Buda engine components was used to evaluate field samples of Galena RD-76. In early screening tests it was found that bearing failure could not be induced unless water was added to the used oil sample (4% every 24 hours).

This data confirmed the unsatisfactory performance of the oil in use in 1960 and 1961 (probably produced in 1959) for bearing lubrication in the presence of water while earlier samples performed satisfactorily. This shift in performance occurred at a time when coolant leakage into the crankcase oil was becoming a significant factor as previously noted (Table 12).

The next step was to simulate the bearing failures in an engine test. The Buda diesel single cylinder engine already used in the development of RD-76 was chosen. Tests were run without water addition on 1956 through 1960 production samples of Galena RD-76 and no bearing failures were obtained on the main bearing rig when the Buda used oils were run for 150+ hours.

However, when coolant water was added to the test oils in the 300 hour Buda test and the used oils submitted for main bearing rig tests, then the 1959 production failed within 31 hours. Further evaluations were made to assess the effects of additive components and base stock processing.

The oils were run with coolant addition in the 300 hour Buda test and then in the Buda bearing rig to determine if there was a difference (a) between hydrofinished and clay treated stocks, (b) between different sources of PARANOX 24, (c) between different processes for PARANOX 47. The following Table indicates the effects of these changes on lubrication of the main bearing rig.

TABLE 13 EFFECT OF ADDITIVE AND BASE STOCK CHANGES ON MAIN BEARING LIFE AFTER COOLANT ADDITION

PARANOX 24 Source:	Hydrofinished Base		Clay Treated Base	
	Sonneborn	Bryton	Sonneborn	Bryton
PARANOX 47 1960/05	Fail	Fail	-	Pass
1960/10	-	Borderline	-	Borderline
1961	-	Pass	-	-

These bearing rig data, while not complete, do imply the following:

1. PARANOX 24 source was not critical.
2. Hydrofinished base was more sensitive to water with this additive system.
3. PARANOX 47 showed inconsistent bearing performance (with coolant contamination) ranging from 1960 fail or borderline fail to good performance in 1961 in the hydrofinished stocks. However, the May 1960 sample which failed in the hydrofinished stocks, passed in the clay treated stocks.

Further investigations showed that oils which "failed" the bearing rig test would give a "passing" result if an oil filter which significantly reduce the pentane insolubles was used.

Examination of the failed bearings showed considerable evidence of dirt particles embedded in the overlay in heavily loaded areas.

This suggests that some oil samples experience an inability to hold the dirt in suspension in the presence of coolant contamination and under lubrication conditions in the loaded bearing.

4.2.4 Overall Conclusions

1. Laboratory investigations showed that Galena RD-76 samples representative of 1956-61 production gave satisfactory performance in both engine and bearing rig tests run in the absence of water contamination.
2. In the presence of water contamination, it was shown that 1959-61 samples of used oil from both field and laboratory engines gave poor bearing life, confirming customer field observations.
3. This coolant contamination was clearly increasing over the period 1958-60 presumably due to some deterioration in railway maintenance practices. This may have been caused by the perceived 'quality cushion' in Galena RD-76 which had in fact been used up by the extended oil drain practices introduced in 1956. The engines were obviously 6-8 years old by the time of the field problems.
4. Galena RD-76 manufacturing changes in both additive and basestock processing appeared to contribute to water sensitivity and inferior bearing lubrication when this contaminant was present. The mechanism was not clear but there were some indications that inability to hold dirt in suspension at bearing surfaces which caused disruption of the oil film may have been a factor.

Specifically, PARANOX 47 quality consistency when in hydrofinished basestocks in 1960 was considered to be suspect. This does not explain earlier engine cleanliness deficiencies and oxidation problems noted in 1958. Therefore, the change from batch process NPS to continuous process NPS in 1956 and the overbasing change in 1957 to PARANOX 47 might be considered as more of a factor than the change from clay treating to hydrofinished basestock in 1959.

5. The most probable conclusion is that Galena RD-76 quality was fully stretched by the extended oil drain practices and deteriorating maintenance practices of the perhaps 'complacent' railways. Coincidentally, additive and basestock changes made the oil more sensitive to coolant contamination, leading to more rapid deterioration in performance particularly with respect to main bearing failures.

The fact that some field failures occurred without coolant contamination being identified, suggests that this formulation may have become particularly sensitive to pentane insolubles level in terms of its bearing lubrication performance.

The above problem has been discussed in some detail as it is a good example of the complexity of solving engine oil field problems. Rarely are all the critical facts available and often there are a number of contributing factors involving both the hardware and the lubricant which, over a period of time, combine to result in a serious problem. The continuing challenge is to anticipate such problems and aim at satisfactory solutions before business is lost to competition. Correspondingly, operating problems being experienced with competitive products provide unique opportunities to gain new business if solutions can be rapidly found.

4.3 GALENA RD-40 Development (1966-)

By 1962, the stage was set for reformulation to a new additive system which would overcome the field problems and provide improved overall performance. Esso Research and Engineering Company had developed, under licence, a new component, LB-946 (calcium amino nonyl phenol or CANOP). This was incorporated into two field test oils QS-109M, QS-109P along with PARANOX 24 and Oronite 1210 ashless dispersant (109P only). QS-109M gave dirty engines and high piston undercrown deposits while 109P gave clean engines but still high undercrown deposits. QS-109R using Enjay's PARANOX 74 was similar to 109P. In severe freight service at Quebec Cartier Mines, the CPR and the Quebec North Shore and Labrador Railway, these experimental oils all gave excessive piston undercrown deposits and eventual piston cracking. These failures in total, cost Imperial about 400 k\$ in repair bills for engines under field test through 1964. PARAMINS (Enjay Chemical Company) shared this cost with Imperial.

In 1963, EMD introduced a new 645 cu in/cylinder locomotive (GP 35) rated at 2500 HP and GE introduced its new 3000 HP locomotive in the U.S.

Standard Oil of California introduced its Custom Plus oil which had been successfully field tested in these new units. Chevron Chemical offered a modified but similar additive technology to the Custom Plus system which was attractive to Imperial in view of the problems with Esso Research technology.

Accordingly, QS-109XB containing 8.2 vol% Oronite 2492S in LCT 40 base and QS-109R were compared on the CPR in 6 brand new GP-35 units in severe freight service. After 100,000 miles, the QS-109R (PARANOX 74) was dropped because of excessive undercrown deposits and dirt levels but 109XB continued for 200,000 miles showing excellent performance. Similar experience on the

CNR and QCM 567C units in severe service resulted in cancellation of Galena RD-76 and the branding of QS-109XB as Galena RD-40 in 1966 (RD-40 was 7 TBN level.)

At this time, the CPR/CNR increased the major overhaul point to 500 k miles.

Later in the 1960's, MLW introduced 3600 HP units and EMD brought out 20 cylinder units rated at 4500 HP in the U.S., but the SD-40 rated at 3000 HP was the main type offered in Canada (16 cyl carrying 3000 IG of fuel and 330 IG of crankcase oil) with the 645 E3 engine.

A demand for 'second generation' 10 TBN oils for the E3 engines in the U.S. prompted field test work by Imperial in Canada to meet a possible future demand for these oils in other engines. Accordingly in 1971, field tests in 3000 HP EMD and 3600 HP MLW locomotives were started on both Oronite and PARAMINS 10 TBN formulations in LCT-40 stocks. Little advantage over Galena RD-40 was seen but PARAMINS appeared to have caught up to Oronite using a Surpass Chemicals developed calcium sulphurized phenate in a total formulation developed at Sarnia. In the U.S., PARANOX 75 (PARANOX 105/24 + LZ-89 + Sulphurized Sperm Oil) achieved some success but was not significant in Canada. By 1972, it became apparent that naphthenic basestock availability worldwide was declining. Accordingly, EMD was persuaded to allow warranty field testing of higher VI paraffinic basestocks in new locomotives with the 10 TBN level additive packages.

In January 1973, 16 EMD SD 40-2 CPR locomotives were put on test with MCT 30/60 basestocks and the two competitive 10 TBN packages. Nine more GP-40-2 CNR locomotives were added to the test program in early 1974. These tests were continued for mileages in the range of 300 k using GALENA RD-40 as the base case comparison. Satisfactory performance was shown for both 10 TBN packages but insufficient advantage over RD-40 existed to justify their higher cost adoption in the then current environment of normal quality diesel fuel and moderate engine severity.

However, the incentive to use MCT basestocks was sufficient to justify further field testing at the 7 TBN level of both PARAMINS and Oronite packages. The PARAMINS formulation was designated Oil #2572 and the Oronite was Oil #2055. Oil #2055 ran in 4 SD-40-2 locos on the CPR at Calgary. Oil #2572 ran in 12 SD-40-2 on the CPR at Calgary and 2 GP-40-2 on the CPR. After about 300 k miles, both test oils were found similar to RD-40 in performance and essentially equivalent to the 10 TBN formulations in the MCT stocks. This allowed Imperial to offer field tested high VI oils at competitive cost should they be required in case of a TJ-102 basestock shortage. These oils were given a "limited use" status on the EMD Pointers List which meant careful monitoring of field performance was required should they become commercial. Supply of TJ-102 (LCT) basestocks ended in mid-1979 and a shift to MCT 30/60 stocks followed by a shortage of MCT-60 quickly developed. It was found that the PARAMINS formulation needed less MCT 60 and it was branded GALENA RDH-40 and firmly recommended to the railways. The railways preferred the long service Oronite technology and shifted to other suppliers, causing a significant loss of volume to Imperial. Imperial reintroduced the RD-40 formulation, however, the lost volume was never regained.

The next area of Research Department focus was development of a Fuel Efficient Railroad Oil to respond to the rapid escalation of fuel costs that had occurred during the 1970's energy crisis.

4.4 Development of Fuel Efficient Railway Oils

As a result of increasing diesel fuel costs and the desire to have a multigrade oil for cool weather shutdown and startup, the railways were quite receptive by 1978 to testing 20W40 oils.

Several formulations were developed and by 1981 full scale testing, in an EMD SD-40 locomotive leased from the CNR, was started at Sarnia.

Fuel economy testing was also carried out in the Sarnia 6 cyl Chevrolet gasoline engine but results were inconclusive.

Results from the full scale SD-40 testing showed that only QS 8703C 20W40 (3 vol% Acryloid 953R/11.4 vol% ECA 5185) with ECA 7812 friction modifier and QS 8704A (9.2 vol% Oronite 2894) with ECA 7812 and ECA 8835 friction modifiers showed promise and this was marginal.

The current situation is as follows (late 1985):

- o C.P. Rail did adopt 20W40 oils but found savings marginal and may revert to SAE 40 products.
- o CNR is running durability field tests with 15W40 oils and plans to bring out a new SAE 40 purchase specification with a viscosity limit of 13 cSt \pm 0.3 at 100°C to try and derive viscometric fuel savings versus the usual 14 cSt level.

To summarize, although the Research Department expended considerable time and effort in this program, the results have been only marginally successful and the benefits of friction modifiers questionable. At the same time, the effort has considerably enhanced the relationship with the technical personnel in the two major railways and it is hoped that this enhanced relationship will benefit Imperial's market position longer term.

5.0 GAS ENGINE OILS

5.1 Introduction

Along with the Leduc oil field discovery in 1947, came the development of natural gas fields and the subsequent transmission industry growth. Initial collection via small pumps and lines grew into major pipelines across Western Canada. The pumping needs resulted in the rapid application of the gas as a fuel for stationary engines. These engines were used mainly for driving pumps but local electrical power generation became an important secondary application.

Initially, the naturally aspirated 2 and 4 cycle engines appeared to be satisfied with MIL-L-2104A low or medium ash oils (e.g. ESSOLUBE HD or HDX) or even straight mineral oils such as MINERALUBE, provided adequate filtration/conditioning was provided. However, with the introduction of large turbocharged gas engines around 1960 (e.g. Cooper Bessemer LSV-16T), some lubrication problems began to emerge. At first, it was thought that higher detergency oils would be the answer, particularly with sour gas (high sulphur level). This proved to be a successful approach in the Waukesha engines, but only where barium formulations such as PARANOX 205 were used. Barium was superior to calcium in controlling combustion chamber deposits and therefore in controlling pre-ignition.

In the Cooper Bessemers, this approach was not as successful and it was learned that Standard Oil of California was having more success using highly dispersant low ash formulations. In these oils, mixed alkyl and aryl ZDDP were used to stabilize the base oil and dispersant. They also gave excellent results in combatting nitration which gave a serious oil thickening problem in these large engines running on very lean mixtures. These engines were close to pre-ignition at full output and required less than 0.5 wt% sulphated ash oils to avoid pre-ignition from combustion chamber deposits.

5.2 ESSOLUBE G

After field testing of QS-800 (~8% PARANOX 65) at Saskatchewan Power Corporation had proved unsuccessful for the reasons noted previously (excessive combustion chamber deposits, plug fouling and pre-ignition), a new low ash Stan Cal type formulation was placed on test in 1963.

Immediately, successful performance resulted in the branding of the new formulation (7.6% OLOA-1215 in MCT-30) as ESSOLUBE G-30.

This one formulation ultimately gained over 60% of the Canadian gas engine market for the Company. QE-1371D containing 8.6 vol% ECA-7004 was developed by PARAMINS at Sarnia in 1973 as a G-30 alternate formulation but was never commercially adopted after field testing revealed a possible rust debit with wet gas.

In 1969, ESSOLUBE G-10 was developed to provide improved starting at low temperatures for small Ajax one and two cylinder engines at well gathering systems, also for propane or LPG vehicles in winter operation.

Oil #2243 was developed to meet the Waukesha Lubricating Oil Recommendation #1015-L dated January 1969 which specified a 2.0-3.4 wt% ash level of barium, calcium or both with a maximum of .03 wt% zinc. QE 2243A, at the 3.4% ash level did not perform well and was replaced in 03/1970 by QE 2243B at the minimum level of 5000 ppm of barium and/or calcium but this fell below the 2% wt minimum and was replaced in 05/1970 by QE 2243C at the 2.1% wt ash level using a downtime of PARANOX 205 at 8.7 vol% (5.8% ENJ-20P + 2.9% PARANOX 43). This formulation is still in use in 1985.

Waukesha's November 1984 Lube Oil Recommendation reduced the minimum sulphated ash level from 2% to 0.35% by weight for the VHP gas engine series for which Oil #2243 was developed to reduce valve and seat wear.

In 1985, ESSOLUBE GLX-30 was introduced based on the same additive treatment (8.75 vol% PARANOX 206) as Exxon's ESTOR GLX series with over 16 years satisfactory performance in the U.S. This formulation was developed to meet the new Waukesha recommendations of November 1984 shown above.

A multigrade fuel efficient, ESSOLUBE G 15W40 brand containing 7.6 vol% OLOA 1215/6.1% Acryloid 953R/0.1 ECA-7812 (LA-161) and 0.16% Acryloid 154C was marketed in 1985. Primary application is to provide better low temperature starting and lubrication than G-30 at remote or unheated locations. MCT-10 is the base stock.

In 1984, a low temperature multigrade oil, ESSOLUBE G 10W30, was recommended for year round use in low horsepower natural gas engines where G-10 would be recommended in winter operation. Formulation is similar to G 15W-40 except that MCT 5/10 is the basestock.

Based on ESTOR AGX-30 but using MCT stocks, ESSOLUBE AGX-30 (1985), contains 7.8 ECA-9065D to provide excellent ashless gas engine oil performance in applications such as the Cooper Bessemer 2 cycle engines of over 85 BMEP/cylinder. It replaced Oil #1381 which was developed by Research at Sarnia in the 1968-73 period.

6.0 CONCLUSIONS

It is evident from the preceding survey of Imperial's engine oils that the area has been an extremely active one in Imperial's history. New product and grade introductions and reformulations prompted by changing industry and marketplace requirements, by field performance problems and by supply and cost considerations have occurred frequently with most of the product lines and reflect the responsiveness to industry and customer requirements that has been largely responsible for Imperial's success in the marketplace. Where this responsiveness has been lacking, customers have been lost; when response has been fast new business has been gained.

Several important conclusions can be drawn from this survey:

1. A keen awareness of industry trends, customer preferences and available technology by research and technical service departments is a key factor in the successful development of new products in a cost efficient manner.
2. Close contact with the field and prompt investigation of field problems is essential to maintaining the performance level of products and customer satisfaction.
3. While product reformulation is essential to correct deficiencies and keep pace with evolving equipment needs, changes dictated by cost and supply considerations with no obvious customer benefit must be managed carefully. Customer confidence takes many years to establish but can be lost extremely quickly.

Engine oils continue to be an active area. Indeed, with the complexity of today's additive systems and the ever-increasing performance demands being placed on engine oils by equipment builders, the pace of activity continues to increase.

At the same time, these increased performance demands have added considerably to the costs of developing and qualifying new additive systems and products.

Today's challenge is to anticipate future needs such that the available resources can be closely focussed and needed product developments accomplished in the most cost-effective manner. It is hoped that, in some measure, this history will help this challenge to be met.

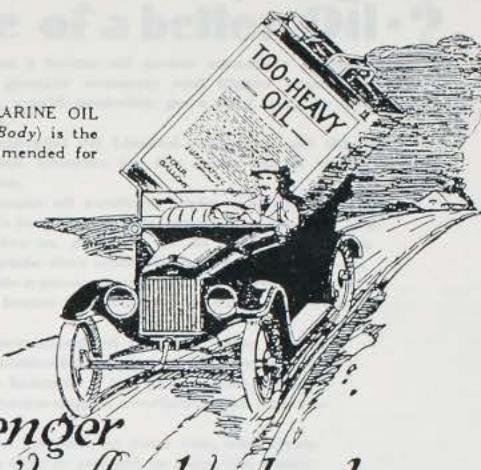
APPENDIX

IMPERIAL OIL LIMITED



Remember

IMPERIAL POLARINE OIL
(Light Medium Body) is the
lubricant recommended for
your Ford.



A Passenger You can't afford to haul -

Briefly, these are some of the results of using too heavy an oil for your Ford.

- (1) Engine drag and loss of power.
- (2) Improper oil distribution.
- (3) An overheated engine.
- (4) Excess carbon deposit.
- (5) Unnecessary friction and wear.
- (6) Large repair bills.
- (7) Rapid depreciation.
- (8) Excess fuel and oil consumption.

What is the remedy? Use Imperial Polarine Motor Oil (Light Medium Body), which is especially adapted to the mechanical requirements and operating conditions of your Ford engine.

Have your crank case cleaned and refilled today with Imperial Polarine Oil (*Light Medium Body*), and realize full Ford economy and efficiency.

IMPERIAL OIL LIMITED

*Manufacturers and Marketers of Imperial Polarine
Motor Oils and Marketers in Canada
of Gargoyle Mobiloid.*



Made in five grades for the proper lubrication of all makes of automobiles, trucks and tractors.

How far would you go to be sure of a better Oil-?

Knowing that a better oil means smoother performance, longer life, greater economy and bigger trade-in-value for your car, you'd probably go a long way to be sure of a better oil.

That's what Imperial Oil Limited did--went all the way to tropical South America for the crude out of which to refine Marvelube.

There's lots of crude oil available right at Canada's front door. If Canada's largest and most modern refineries had been able to evolve as good an oil as Marvelube from locally available crude they would have been glad to do so. Peruvian crude made a purer, carbon-free, fuller-bodied oil--an oil that meant better lubrication--so Peruvian crude was decided upon.

The decision set a new standard in motor oils. Aircraft operators, the most particular buyers of oil, are enthusiastic about Marvelube because it has given them a longer period of operation between engine overhauls, and a greater margin of safety.

You can enjoy the same benefits in your car, and there is a grade of Marvelube that is refined to meet the exact requirements of your car. Consult the Marvelube chart at good service stations and dealers everywhere.

Marvelube

A Better oil made from Peruvian Crude



IMPERIAL OIL LIMITED
EVERYWHERE IN CANADA

Ad 324A
3 Col. x 200 lines

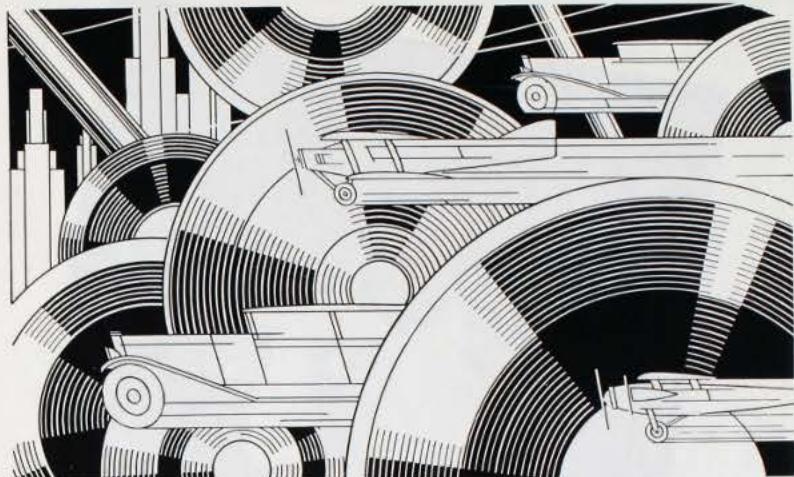
An IMPERIAL DEALERSHIP
*is the most desirable franchise
in the field...*

TEN thousand dealers on every highway from coast to coast have hung out the Imperial oval sign because they know that this sign identifies their station as a good place to buy gasoline and motor oil. They know that the motoring public is already sold on the high quality of Imperial Products and they are confident that Imperial will help to keep them sold with widespread advertising, up-to-the-minute sales helps, and co-operative merchandising plans.

An Imperial franchise is a double guarantee. Backed by real service, it assures you of good customers and it assures your customers of good products.

IMPERIAL OIL LIMITED





Riding abreast of the times

You expect more from your motor car today than you did ten years ago. And you get it. Greater speed, smoother power and more responsive performance are common to modern cars as a result of the development of higher speed, higher compression motors.

These improved engines demand a better oil—fuller-bodied, with greater resistance to heat and wear.

To ensure a better motor oil, Imperial Oil Limited goes all the way to Peru for the crude from which to make Marvelube.

Marvelube is made from a base that is rich in all the qualities necessary for better lubrication of the modern motor. It is today the oil standard for high-speed motors from coast to coast.

Marvelube is preferred by over half a million motorists in Canada and is the choice of aircraft operators because of its superior lubricating qualities.

There is a grade of Marvelube refined to meet exactly the specifications of your car, truck or tractor. Consult the Marvelube Chart at Imperial Oil stations and dealers.

Marvelube

From far Peru comes a better crude
to make a better motor oil

IMPERIAL OIL LIMITED
EVERYWHERE IN CANADA

Ad 428A
5 1/2 x 19 3/4 in.



**"NOT CHANGED
YOUR OIL YET?"**

THEN how about a new winter oil that will give you from 40% to 50% easier starting and thus save battery wear — an oil that's free from gum forming substances? . . . Two new winter grades of

Marvelube are now on sale. Here are some facts about them. They flow readily at temperatures below zero . . . These new Marvelube winter grades are the lowest carbon pro-

ducers on the market — bar none! That means a clear motor for you . . . In spite of the fact that these oils flow freely at such low temperatures, they never burn them. Only body heat can melt them. Ordinary winter oils are thin enough to flow at low temperatures but break down under heat. Not so with Marvelube. Protect your engine the sure way — change now to Marvelube.



IMPERIAL OIL LIMITED
STATIONS AND DEALERS EVERYWHERE IN CANADA

Ad. No. 1034A (Revised)
4 cols. x 250 — 1500 lines
Newspaper, 1935

The advertisement is from
COCKFIELD, BROWN & COMPANY LIMITED
PRINTERS, 1935

HIGHER SPEEDS, TEMPERATURES,
PRESSURES!



So SCIENCE MADE THIS
BETTER OIL

● The efficiency of the modern automobile engine has advanced a long way over the engine of a few years ago. It is 25% smaller, its weight has been decreased 35%, yet it develops double the horse power.

The modern engine runs faster and consequently hotter. Clearances between bearing surfaces have been reduced while compression ratios have been increased.

Lubrication, therefore, is more important than ever. The New Marvelube developed in Imperial Oil research laboratories is engineered for the faster, hotter running engines of today.

The original Marvelube has long been a leader among motor oils. The New Marvelube retains all the original high qualities—now also it possesses these improved characteristics:

It lasts longer. At today's high speeds and temperatures it gives maximum oil mileage.

It keeps engines cleaner. It will give you that lively feeling of instant, surging power. Wear is reduced. Upkeep costs come down. So, take advantage of this outstanding new oil—now! Drive in where you see the Imperial Oval Sign.



the
NEW **Marvelube** **MOTOR**
OIL

SOLD BY IMPERIAL OIL DEALERS  EVERYWHERE IN CANADA

Ad. No. 402
5 c.c. x 200 lines = 1000 lines
Newspapers, 1940



characteristics

- Premium Multigraded Oil
- Meets car makers "SE" requirements
- Meets:
FORD M2C101C
FORD M2C101B
GM 6136M
GM 6041M
- Warranty approved
- Permits long oil drain performance
- Recommended for all cars

application

- Grades:
10W-30 recommended for year round, except severe winter driving.
5W-30 recommended for year round except severe summer driving

characteristics

- Premium Single Grade Oil
- Meets car makers "SE" requirements
- Meets commercial vehicle "CC" requirements
- Meets:
FORD M2C101C
FORD M2C101B
GM 6136M
GM 6041M
- Warranty approved
- Permits long oil drain performance

application

- Grades:
10W, 20W-20, 30
Above 32°F—use 30 or 20W-20
Below 32°F—use 10W
Recommended for all cars with single grade oil requirements

characteristics

- Premium Multigraded Oil
- Meets car makers "SE" requirements
- Meets:
FORD M2C101C
FORD M2C101B
GM 6136M
GM 6041M
- Warranty approved
- Permits long oil drain performance

application

- Recommended for all cars
- Grade 10W-30
Recommended for year round, except severe winter driving



engine oils



characteristics

- High Performance Multigraded Oil
- Surpasses car makers "SE" requirement
- Exceeds: Ford M2C101C and M2C101B GM 6136M and 6041M
- Warranty approved
- Permits long oil drain performance
- Provides maximum engine protection

application

- Recommended for all cars
- Grades:
 - 10W-50 recommended for: year round including severe summer (high speed and heavy load etc.) and moderate winter driving
 - 5W-40 recommended for: year round including severe winter driving

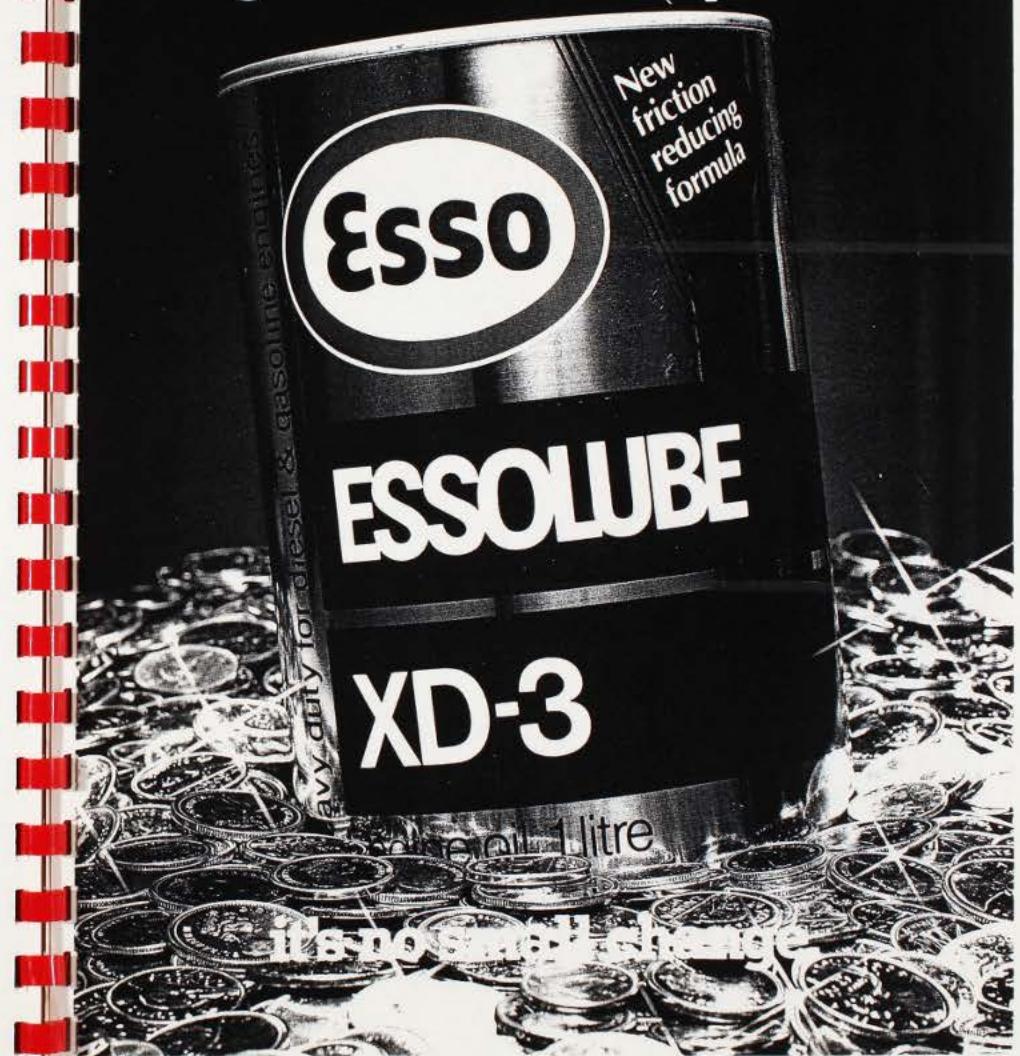
After 5 years of road-testing on 200 different diesel engines, in 9 different locations, over 35,000,000 actual test miles, Imperial Oil can now recommend a 25,000 mile oil change interval for Essolube XD Multigrade & Essolube XD-3. No special techniques are required - just good maintenance procedures and Essolube XD Multigrade.



**Oil so good
it can save
gas.**



When an
engine oil can save you fuel





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